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# The Truth Between the Teeth: An Analysis of Interproximal Tooth Wear at the Ables Creek Cemetery

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## ABSTRACT

Current archaeological knowledge suggests that, by the Late Mississippian period, inhabitants of the southeastern United States had adopted maize agriculture and that maize was a key component of the normal diet. However, in some regions where wild food resources were easily attainable, there is evidence that the transition to agriculture was delayed or did not occur at all. This thesis examines Late Mississippian skeletal collections from two sites in eastern Arkansas, Ables Creek and Upper Nodena. Analysis of differences in interproximal tooth wear facet size and caries rates between the two populations reveals that the diets at these roughly contemporary sites were markedly different. The data collected and presented in this thesis reveals that the Ables Creek skeletal sample has significantly larger interproximal wear facets and dramatically lower caries rates than the Upper Nodena skeletal sample and discusses the possible cultural and ecological factors that could have led to this dietary difference. Additionally, this thesis introduces and assesses a new method for quantifying interproximal wear facet size.

This thesis is approved for recommendation
to the Graduate Council.

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I would also like to thank the staff at the Arkansas Archaeological Survey and the Quapaw Tribe of Arkansas, who allowed me access to the Ables Creek and Upper Nodena skeletal collections, which form the basis for this project.

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## DEDICATION

To my daughters, Annabelle and Madeleine, who motivate and inspire me.

And

To Randy, who held everything together.

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# CHAPTER 1: INTRODUCTION

It has been widely assumed that, by the end of the Late Mississippian period, the inhabitants of the southeastern United States had adopted maize agriculture and that maize was a significant part of the normal diet. Countless studies have been conducted on health changes at the transition to agriculture (e.g. Cohen and Armelagos 1984, Lambert 2000), but some have cautioned that focusing solely on subsistence leads to explanations that ignore the complicated interplay of cultural and ecological variables that also play a part in changing health status during the Mississippian Period (Lambert 2000:1).

The purpose of this thesis is to introduce a new method for quantifying the size of interproximal wear facets and, using data collected using this method, explore the dietary differences between the inhabitants of the Ables Creek site (3DR214) and the Upper Nodena site (3MS4). Additionally, this research project incorporates analyses of cultural and ecological factors that could have played roles in the development of different subsistence strategies at these two Late Mississippian sites in eastern Arkansas.

The results of this study reveal important information about subsistence in the Lower Mississippi Valley during the Late Mississippian-early protohistoric period. Despite the prevailing assumption that maize agriculture was the key component of the diet of prehistoric Native Americans in all areas of the Southeast at this time, research such as this suggests that there are numerous factors that might have led even late prehistoric populations to continue to rely on wild food resources instead of cultivating and consuming maize.

Although the Ables Creek and Upper Nodena sites were occupied at roughly the same time, the amount of interproximal wear and caries rates at the two sites are markedly different, indicating different dietary strategies. Cultural factors such as social status could have resulted in significant differences between the groups. Environmental factors, such as an abundance of easily attainable wild food resources in one area that were not available in another could result in different subsistence strategies. Dramatic climate change around 1550 AD could also have had a profound effect on the diets of all populations living in the Mississippi Valley at the time, evidence of which is seen in only the latest prehistoric populations like Ables Creek. The archaeological, paleoecological, and bioarchaeological evidence that supports each of these potential explanations will be explored in detail.

This thesis is divided into six chapters. The first chapter serves as an introduction to the research questions and methods that will be used to test hypotheses about subsistence at Ables Creek and Upper Nodena. The second chapter provides background information about the Ables Creek and Upper Nodena sites, including general descriptions of the sites and information about subsistence and mortuary practices, and also includes a discussion of ecology and subsistence in the Lower Mississippi Valley. The third chapter provides essential details about the usefulness of tooth wear analyses in anthropology and a description of interproximal wear, its causes, and the implications of different interproximal wear rates. The fourth chapter introduces the specific hypotheses to be tested, includes a discussion of previous bioarchaeological work conducted on the Ables Creek skeletal collection and problems with the collection, and describes the specific methods for data collection used in this project. The fifth chapter reports the results of the analyses conducted on both the Ables Creek and Upper Nodena skeletal collections. Chapter six presents interpretations of the reported results, explores the possible explanations for them, and suggests areas for future research.

# CHAPTER 2: BACKGROUND INFORMATION

## A) THE ABLES CREEK SITE

### *General Information*

The Ables Creek site is a late Mississippian-early Protohistoric site in southeast Arkansas (Jackson 1992). The site was discovered and brought to the attention of the Arkansas Archaeological Survey in September 1986 after a human bone was uncovered during land planing (Jackson 1992:9). An emergency excavation was organized and carried out by University of Arkansas undergraduate and graduate students, Arkansas Archaeological Society members and other volunteers under the direction of Edwin Jackson (Jackson 1992:9). The primary goal of the excavation, which was limited to three weekends during September 1986 and a few follow-ups in January and March 1987, was to remove the human skeletal material and uncover as many artifacts as possible (Jackson 1992:11). During this limited excavation, approximately 48% of the site area and 56% of the cemetery was excavated (Jackson 1992:11).

The Ables Creek site is located in the immediate vicinity of Bayou Bartholomew in northeast Drew County, Arkansas (Jeter 1980:57). It is located on a relict natural levee near the confluence of Bayou Bartholomew and Ables Creek (Jackson 1992:9). Bayou Bartholomew is located on a meander belt of the Arkansas River that was abandoned before 1000 AD (Jeter 1980:57). The location of the site and its proximity to Bayou Bartholomew has significant ecological implications for assessing subsistence practices at Ables Creek.

While the Ables Creek site can be confidently placed in the Mississippian period, there were some difficulties in dating the site more specifically. Based on ceramic evidence, it is possible that the Ables Creek site was founded as early as the late 14th century but Jackson contends it was more likely founded in the mid-15th century (1992:90). There is clear evidence of intense use during the 16th century and, although there is very little evidence to provide a date for the termination of cemetery use, the recovered artifacts indicate that the latest date for cemetery use is in the early 17th century. Based on all of the available evidence, it is likely that the Ables Creek site dates from approximately 1450 AD to 1600 AD (Jackson 1992).

There are two competing opinions as to what group occupied the Tillar complex, which includes Ables Creek. Jeter contends that the inhabitants of the Tillar complex were ancestral to either the Tunica or Tunica-speaking Koroa groups (Jeter 1986). Others contend that the Tillar complex represents a group amalgamation due to regional depopulation that resulted from European contact (Tiné 1996:10). Regardless of who the inhabitants of the Tillar complex were, they are representative of the populations in the Lower Mississippi Valley during the late prehistoric and early Protohistoric periods (Jackson 1992:5).

***The Ables Creek Mortuary Program***

The human remains recovered from the Ables Creek cemetery are the largest collection of human skeletons in the Tillar complex and, as such, are very important to understanding mortuary practices in the late Mississippian-early Protohistoric period in southeast Arkansas. However, analysis of the mortuary program is complicated by the extreme disturbance at the site. Both pot hunting in the 1930s and more recent agricultural activity led to significant disturbance of both burial and artifact distributions (Jackson 1992:12). Jackson estimates that approximately 30 to 40% of the primary inhumations at the site are either commingled or missing entirely (Jackson 1992: 11). Despite these issues, it is highly likely that the Ables Creek site represents a cemetery used by a single group of people for approximately 150 years (Jackson 1992:110). Additionally, Jackson believes that the excavations, although limited, recovered approximately 75 to 80% of the burials present at the site (1992:15). Because of these facts, the cemetery and the mortuary practices represented within it provide a unique glimpse into the mortuary practices of the Lower Mississippi Valley during the late prehistoric-early protohistoric period.

During excavations at the Ables Creek site, 102 graves were excavated containing approximately 133-137 individuals (Jackson 1992:15). Additional osteological analysis revealed approximately fifteen previously unrecorded individuals. A wide variety of burial types are represented at the cemetery including primary inhumations of adults and sub-adults in both single and group burials as well as a number of secondary burials (Jackson 1992:12). The majority of primary burials were extended, supine with a general south or southeasterly orientation (Jackson 1992:12). Twenty-one of the burials were clearly associated with grave goods (Jackson 1992:19) and four burials appear to involve greater artifact associations than all others (Jackson 1992:17-18). Despite this, there is no indication of clearly differentiated social status within the cemetery (Jackson 1992: 18).

Obtaining chronological control of the use of the cemetery has proven to be extremely difficult. Because of the level of disturbance, there is no stratigraphic evidence available to establish a timeline of cemetery use and, therefore, Jackson was forced to rely on the horizontal distribution of both burial and artifacts to develop a loose chronology for cemetery use (Jackson 1992:102). One of the more striking aspects of the Ables Creek mortuary program is the diversity in burial types that suggest a change in mortuary practices at the site over time, so it was necessary to develop a sense of change over time.

Jackson contends that the southern portion of the cemetery is likely the latest portion of the cemetery based on several lines of evidence. First, artifact distributions (specifically ceramic types) within the cemetery indicate a later date (Jackson 1992:103). Operating on the premise that there was major demographic change during the cemetery's use, the presence of more densely packed burials and intrusive burials in the southern portion of the cemetery also supports a later date (Jackson 1992:102). However, the south or southeasterly orientation of the vast majority of burials at the site and the lack of a clear boundary within the cemetery prevents further differentiation of the cemetery (Jackson 1992:101).

The Ables Creek cemetery is also of particular interest because it appears to deviate from the standard Mississippian mortuary practice involving mortuary processing in that it contains an abundance of primary inhumations (Jackson 1992:112). Jackson has two hypotheses to explain this. He posits that it is possible the site was abruptly abandoned or that there was an increased mortality rate at some point during the cemetery's use that forced the inhabitants to forgo secondary burial treatments (Jackson 1002:112).

Examination of the Ables Creek site in contrast to other Tillar complex sites provides additional hypotheses. As indicated above, the Ables Creek cemetery differs from other Tillar complex sites because there are significantly fewer secondary internments relative to primary interments (Jackson 1992:12). There is no evidence of mound building or charnel houses at Ables Creek (Jackson 1992). Assuming that Ables Creek and other Tillar complex sites with a mortuary component represent a single mortuary precinct, Jackson suggests that the archaeological evidence indicates that the Ables Creek cemetery could represent formative stages of Tillar complex development (1992:110) or a different social group or a group with different social status (1992:111). Based on the available evidence, it is possible that Ables Creek represents a lower status group within the Tillar complex, although there appears to be relatively little inter-site status differentiation. It is important, going forward, to consider these additional hypotheses.

***Subsistence in the Tillar Complex***

Although there is little evidence relating to subsistence, settlement, economy, or social systems in the Tillar complex, previous analyses of human remains from other Tillar complex sites do provide some information about likely diet. In 1987, McKelway conducted osteological analysis on skeletons recovered from the Tillar site and concluded that the diets of inhabitants at that site was likely composed of soft foods, primarily carbohydrates, indicating a maize-based diet. Osteological analysis by Kerr (1988) at the Austin site reveals caries and porotic hyperostosis rates similar to those in other Lower Mississippi Valley populations. Examination of all osteological analyses of Tillar complex skeletons reveals that there are much lower frequencies of porotic hyperostosis than those of other Mississippian populations which could indicate, in combination with other evidence, a difference in maize reliance.

Ables Creek's location within the general region of the Lower Mississippi Valley and Arkansas River Valley combined with its proximity to Bayou Bartholomew suggests that the inhabitants of the site likely had access to abundant food resources during the time of cemetery occupation. Excavations at Ables Creek, although not conducted with the purpose of reconstructing dietary strategies, recovered a wide variety of faunal remains believed to be associated with subsistence, not ritual. According to the site report, 285 animal bones and bone fragments and 35 mussel shells were recovered from the Ables Creek site (Jackson 1992:96). These bones have been identified as the remains of deer, several small mammals, ducks, pigeons, turkeys, turtles, snakes and catfish (Jackson 1992:99). Because of the limited time available for excavations at Ables Creek, it is likely that evidence of more intense utilization of aquatic resources was missed. Conversations with current residents in the Bayou Bartholomew area reveal that catfish, bream, bowfin, and crappie are still abundant in the bayou and the area is known for a high volume snakes and turtles (Rocky Lindsey DVM, personal communication) suggesting that the residents of the Tillar complex likely also had access to abundant aquatic resources.

## B. THE UPPER NODENA SITE

### *General Information*

The Upper Nodena site, in Mississippi County, Arkansas is one of the most investigated Late Mississippian sites in the Central Mississippi Valley (Mainfort et al. 2007:113). Beginning in the late 1800's, Dr. Hampson excavated several features within in site including hundreds of burials, dozens of house sites and numerous kitchen middens (Mainfort et al. 2007:108). In 1932, the University of Arkansas Museum and the Alabama Museum of Natural History undertook excavations at Upper Nodena with the purpose of obtaining whole ceramic vessels (Mainfort et al.2007:110). While some notes, skeletons, and artifacts from these early investigations remain, the only professional archaeological investigation occurred in 1973 and was led by Dan Morse of the Arkansas Archaeological Survey (Mainfort et al. 2007:111). Since these investigations, a number of researchers have examined various aspects of the site including ceramics, mortuary patterns and social organization, and health and nutrition of the burial population (Mainfort et al. 2007).

The Upper Nodena site is located near Congress Ridge, a relict levee of the Mississippi River in the Saint Francis Basin (Mainfort et al. 2007:108). It is located in the northernmost portion of the Lower Mississippi Valley, an area archaeologists refer to as the Central Mississippi Valley (Mainfort et al. 2007:108). The site's position in a major meander belt region within the Mississippi Alluvial Valley (Morse and Morse 1983:301) and exposure to regular flooding resulted in the soils at the site being very nutrient rich (Mainfort et al. 2007). Indeed, even today, the soils in the region of the Upper Nodena site are considered among the best in the area for modern agricultural production (Mainfort et al. 2007:108).

The Upper Nodena site is the largest site associated with the Nodena phase and good radiocarbon dates are available for some areas of the site (Mainfort et al. 2007: 106). Accelerated mass spectroscopy (AMS) dates of corn cobs recovered in the 1973 excavations provide a calibrated range of 1432-1478 AD while other samples provide a range of 1490-1601 AD but suggest a likely actual date in the mid-1500s (Mainfort et al. 2007:114). Morse and Morse (1983:287) estimate that the site was likely occupied from approximately 1500-1550 AD.

Based on the recovered archaeological evidence, Morse and Morse contend that the prevalence of single-occupation sites in the Nodena phase suggest sudden population increases in the area (1983:283). Further, they suggest that the Upper Nodena site may be an example of abrupt site abandonment at the beginning of the Protohistoric period (1983:287). Regardless of the reasons for the site's occupation or abandonment, it is clear that, based on the density of archaeological sites throughout the Central Mississippi Valley in the Late Mississippian period, that this region supported one of the largest populations in eastern North America at the time (Fisher-Carroll and Mainfort 2000:105).

***The Upper Nodena Mortuary Program***

Fisher-Carroll and Mainfort (2000) have extensively examined the mortuary program and its implications for understanding the social organization at Upper Nodena however, much like Ables Creek, there are problems with the skeletal collection. The earliest excavators tended to only collect whole skulls and post-cranial elements with particularly interesting morphology or pathologies (Fisher-Carroll and Mainfort 2000:107). Additionally, the collections being held by a number of institutions have been reduced over time by factors such as loss, unreturned loans and damage through use (Fisher-Carroll and Mainfort 2000:107).

It is estimated that the total excavated burial population at Upper Nodena was approximately 1,800 individuals but only 893 burials were available or suitable for the analysis of the mortuary program (Fisher-Carroll and Mainfort 2000:107). Fisher-Carroll and Mainfort (2000:115-116) report that there are no obvious differences in grave wealth, energy expenditure, or access to special burial areas (with the exception of those interred in Mound C). They also state that despite the mortuary data not conforming "to the modeled expectation for social ranking," this does not imply that there was no marked status or social ranking at the site (2000:116). For the purposes of this project it will be assumed that the skeletons examined represent a sample of the deceased population at Upper Nodena during the period of occupation.

***Subsistence at Upper Nodena***

The Upper Nodena skeletal collection housed at the University of Arkansas Museum collections was chosen for this project because of the abundance of information available relating to subsistence at the site. Analysis of both faunal and botanical remains recovered archaeologically provides specific insight into the likely diet of the inhabitants of the site.

A large amount of faunal remains were recovered during the 1973 excavations. This evidence indicates that the late prehistoric inhabitants of Upper Nodena utilized a wide variety of wild animal resources, especially white-tailed deer (Mainfort et al. 2007:115). Other animal taxa represented include small mammals, such as rabbits and raccoons, a small number of bear and mountain lion remains, and a variety of aquatic animals including both waterfowl and fish (Mainfort et al. 2007:115).

An equally wide variety of plant remains has also been recovered from Upper Nodena. These remains include a variety of wild plant resources such as hickory nuts, persimmon, black walnut, pecan, wild cherry, hazelnut and pawpaw (Morse and Morse 1983:289). The presence of maize at Upper Nodena is the primary reason this collection was chosen for comparison to Ables Creek. Approximately 98 corncobs and some cultivated beans have been recovered from the site during professional excavations (Mainfort 2010, Mainfort et al. 2007, Morse and Morse 1983). The corncobs recovered from the central area in Feature 8 have been interpreted as the contents of a granary (Mainfort et al. 2007:113) indicating that the inhabitants of Upper Nodena were both actively cultivating corn and were also reliant on maize beyond the growing season. Indeed, zooarchaeological examination of deer remains suggests they were primarily hunted from late Fall to Spring (Mainfort et al. 2007:115). It is likely that hunting supplemented the harvested maize as it was depleted throughout the winter (Mainfort et al. 2007:115).

Morse and Morse (1989:289) state that the corn cultivated at the time in the Central Mississippi Valley was not one of the more stress-resistant varieties and required near perfect growing conditions for successful cultivation. Even with today's highly modified and more stress resistant corn, climate has a major influence on the amount and quality or corn produced. The ideal temperature for growing corn is between 68 and 73 degrees Fahrenheit, with cooler temperatures slowing growth (Wiatrak 2012). Additionally, in order to produce the highest crop yields, corn can require as much as 0.25 inches of water per day (Wiatrak 2012). The difficulties associated with trying to produce maize in less than ideal climactic situations will be addressed later in this thesis.

## C. ECOLOGY AND SUBSISTENCE IN THE LOWER MISSISSIPPI VALLEY

An examination of the ecology of the Lower Mississippi Valley and the subsistence strategies of prehistoric populations living in the region suggests that the people in the Lower Mississippi Valley differed from nearby neighbors because of access to abundant natural food resources. In order to understand the nature of cultural adaptations of the region, it is necessary to understand the characteristics and variability of the river valley environment.

The Mississippi Valley has long been considered a rich region for food and it has been suggested that prehistoric inhabitants likely spent little time hunting or searching for food (Morse and Morse 1983:68). In the Lower Mississippi Valley, the alluvial valley is much larger than in regions to the north and, as a result, the land had greater carrying capacity (Rose et al. 1984:417). Additionally, because of the hydrology of the area, there are more oxbow lakes, natural levees, and backwater swamps. (Rose et al. 1984:403). Recent research suggests that populations in the Lower Mississippi Valley transitioned to maize agriculture at a much later date because they had access to a "vast natural bounty" and almost unlimited access to space (Kidder 1992:33).

Archaeologists working in the Lower Mississippi Valley long believed that, in order for the complex societies present in region to have emerged, they must have relied on maize, bean and squash agriculture (Kidder 1992:15). In the 1920s and 1930s, Henry Collins and James Ford suggested that late prehistoric populations in the region must have relied on maize agriculture as their subsistence base because they assumed that social complexity and agriculture were interdependent. Also, they believed they had archaeological evidence of maize agriculture from very early sites (Kidder 1992:17). Because maize was assumed to be the foundation of Mississippian society, they assumed that maize agriculture was ubiquitous throughout the Southeast United States (Fritz 1995:6). However, recent paleoethnobotanical and faunal exploitation research in the Lower Mississippi Valley challenges the correlation between social complexity and maize agriculture (Kidder 1992:16).

This recent archaeological research provides evidence indicating that the Lower Mississippi Valley was a resource-rich region where hunter-gatherer populations were able to sustain high population density (Fritz 1995:7) because the harvesting and subsequent storing of wild food resources, including aquatic resources, provided both the reliable food base and the food surplus necessary to develop more complex societies (Rose et al. 1984:417). Additionally, the archaeological evidence suggest that prehistoric people in the region sustained a “surprising degree of continuity” (Fritz and Kidder 1993:11) in the ways in which they utilized natural plant resources like chenopodium, iva, curcubits, and helianthus (Kidder 1992:33). In some areas, it is likely that the domestication of native plant varieties dominated the domestication of maize for many more years than previously thought (Fritz 1995:6).

Augmenting the research are new accelerated mass spectrometry (AMS) radiocarbon dates that indicate that the date for the arrival of maize in eastern North American is much later than previously thought, shortening the history of maize agriculture in the region (Fritz 1995:3). According to Fritz, it was once generally accepted that maize was introduced to eastern North America at approximately 1000 BCE but the recent research indicates that the earliest date for maize in the region is 100 CE (1995:6).

There is also substantial evidence for hunter-gatherer groups practicing “sustainable harvesting” of natural resources for many millennia in resource-rich areas even when foreign domesticates were present in neighboring regions and readily available through exchange (Fritz 1995:11). The following examples suggest that the long-term exploitation of wild food resources is a viable long-term subsistence strategy (Fritz 1995:3). It has been widely documented that western North American groups continued to hunt and gather until the arrival of the Europeans and were able to support population densities higher than those believed to have existed in all farming societies north of Mesoamerica (Fritz 1995:3). Additionally, there is evidence that southern Florida populations like the Calusa and Manasota relied only on hunting and gathering even after the arrival of the Europeans (Larsen et al. 2007:30).

In a systematic analysis of prehistoric susbsistence practices during the Coles Creek period, Kidder and Fritz evaluated the hypothesis that the residents were not dependent on maize agriculture but were instead intensifying the domestication of native plant species and relying heavily on animal resouces (Kidder and Fritz 1993:294). Their research, mostly conducted at Tensas Parish in the Lower Mississippi Valley reveals that socially complex hunter-gatherers and fishers continued to harvest wild resources despite the presence of intensive maize agriculturalists in surrounding areas until the end of the Coles Creek period (Fritz 1995:10).

Archaeological research has revealed that, while the Lower Mississippi Valley is a likely spot for some of the earliest horticultural developments in eastern North America, the transition to corn, bean, and squash agriculture in the region probably occurs later here than in most other regions in the Southeast (Kidder 1992:33). The research also suggests that the development of intensified agricultural production was less vital to inhabitants of the Lower Mississippi Valley than to the inhabitants of contemporaneous sites to the north (Kidder and Fritz 1993:294).

# CHAPTER 3: UNDERSTANDING INTERPROXIMAL TOOTH WEAR

In anthropology, tooth wear is often examined as part of osteological analyses because teeth preserve direct evidence of the masticatory behavior of an individual (Smith 1984:39). Tooth wear analyses may yield information about dietary variation, sexual division of labor, the effect of dental pathologies, craft specialization, and food preparation techniques of prehistoric groups (Molnar 1971:176). More broadly, analysis of wear patterns in the dentition can allow researchers insight into important stages in biological and cultural development (Smith 1984:39). It is possible to correlate patterns of dental attrition to the way in which an individual's teeth were used during life (Kaidonis 2008, Molnar 1971, Smith 1984). Direct associations between diet and tooth wear have been established in many species (Kaidonis 2008:S21) and, as a result, there have been countless anthropological studies that attempt to reconstruct diet and tooth use from tooth wear patterns among human populations (Hinton 1982:103). Additionally, comparison of tooth wear patterns among populations with varied diets should reveal significant differences that lead to a better understanding of the cultures under study (Molnar 1971:177).

When analyzing tooth wear, anthropologists typically observe patterns of occlusal wear, but analyses of interproximal wear will also yield important results. The primary cause of tooth wear, both occlusal and interproximal in prehistoric populations is believed to be a combination of the consistency or texture of foods consumed and an increase in the forces of mastication required to process foods within the mouth (Kaifu et al. 2003:49). Anthropologists studying both humans and non-human primates have concluded that tooth wear is a normal physiological process (Kaidonis 2008:S21) and is a persistent feature in human evolution that plays a role in extending the functional life of the dentition (Kaifu et al. 2003:47). Although his theories have been challenged, Begg believes that the occlusal condition resulting from a lifetime of attrition is the normal form of human occlusion (Kaifu et al. 2003:48). Further, he contends that dental issues, specifically crowding and third molar impaction, in modern societies are the unfortunate results of the decrease in interproximal tooth wear (Kaidonis 2008, Kaifu et al. 2003).

Interproximal wear has been determined to be universal in human dentitions because the factors involved in the process are regulated by intrinsic mechanisms (Kaifu et.al 2003:49). Interproximal wear can be identified by the presence of well-defined, somewhat shiny facets in the mesial or distal aspects of posterior teeth. Over time, contact points between teeth become contact areas (Kaidonis et al. 1992:105) and in severe cases these proximal tooth surfaces become worn flat (Kaidonis et al. 1992:105). It is also common to observe concavity on mesial surfaces while the adjacent distal surface remains convex (Kaidonis et al. 1992:105).

Before examining specific trends in interproximal wear observed through analysis of different human populations, it is necessary to examine the causes of interproximal wear. Because of differences in the factors leading to occlusal and interproximal tooth wear, interproximal tooth wear analysis can yield information about diet and masticatory function that is obscured in occlusal wear analysis (Hinton 1982:104). However, studies aimed at analysis of interproximal wear have met with mixed success because of the complexity of factors involved in the development of interproximal wear (Hinton 1982:103). Despite this complexity, it is widely accepted that the extreme occlusal loads that result from the vigorous mastication of fibrous or tough foods lead to the movement of teeth against each other thus producing interproximal wear (Kaidonis 2008, Kieser 1990).

More specifically, the amount and rate of interproximal wear is directly related to both the magnitude and frequency of the forces produced during mastication (Hinton 1982, Newman 1974).

It is thought that interproximal wear is related to two specific forces that act on the dentition: the mesial vector, which acts to maintain teeth in proximal contact with each other, and a bucco-lingual force that results from the lateral movement of teeth during mastication (Hinton 1982, Kaidonis et al. 1992, Newman 1974, Wolpoff 1971). The amount of interproximal wear observed in an individual primarily depends on the mesial force vector (Wolpoff 1971:207). Mesial force vector is simply defined as the mesially directed component of the bite force vector (Hinton 1982:104) or the occlusal forces that act on the long axes of teeth with distally tilted roots (Kaidonis et al. 1992:105). There are several factors that play a role in producing this force. According to Hinton, the most important factor is the mesial angulation of the teeth (1982:104). The pressure the results from the formation and eruption of permanent teeth, the continuous eruption of teeth, contractions of the tongue and buccal walls, the rate of alveolar bone deposition, the action of occlusion on tooth crowns, and the amount of occlusal force on the alveolar margin also are believed to play roles in the magnitude of the mesial force vector (Wolpoff 1971:207).

The other force involved in the production of interproximal tooth wear is the differential lateral movement of teeth during mastication (Hinton 1982:103). Wolpoff states that two factors contribute to the amount of lateral force exerted: the lateral resolution of vertical occlusal forces resulting from tooth angulation and the jaw motions that occur at the alveolar margins (1971:207). It is thought that the muscular activities that occur during mastication result in greater stress on the teeth and the tissues that support them and affects the way the proximal surfaces of the teeth act in relation to each other (Newman 1974:495). Additionally, the relative movement of the teeth as a result of the lateral force causes the mesial aspect of a tooth to wear much faster than the distal aspect of the neighboring tooth which leads to the common pattern of mesial concavity and distal convexity resulting in s-shaped wear facets (Kaidonis 2008:S24). Repeated biting or clenching of the teeth results in greater forces involved in lateral movement (Hinton 1982:104).

Kaidonis et al. have suggested vertical or nearly vertical movements of the teeth also play a key role in the development of interproximal wear facets (1992:106-107). They contend that vertical furrows of various depths widths, and different angles of orientation observed in the interproximal wear facets indicate that it is not solely bucco-lingual movement of teeth that produce the wear (Kaidonis et al. 1992:106-107). They suggest that the s-shaped wear facets and observed "interdigitation" of adjacent teeth support their findings (Kaidonis et al.: 105-106). This group also suggests that consideration should be given to other factors, including tooth alignment, cusp height and morphology, amount of alveolar support, the proximal morphology of adjacent teeth and the width of the masticatory stroke, must also be considered when trying to determine the exact causes of interproximal tooth wear (Kaidonis et al. 1992:107).

Despite the complexity of interaction of the forces that lead to the development of interproximal wear, most researchers agree that that the greatest amount of interproximal wear should be observed in populations with "habitual practices of vigorous mastication" (Hinton 1982, Kaidonis et al. 1992) and that differences in interproximal wear rates indicate differences in the masticatory force exerted by different groups (Hinton

1982:110). Hinton suggests that interproximal wear could be the result of both what was eaten and how that food was prepared (Hinton 1982:111-112). Specifically, he states that raw or dried fruits and vegetable foods require more force to chew while cooked vegetables or meat require less (Hinton 1982:112).

As a result, both occlusal and interproximal wear appears to be more severe among prehistoric groups whose diets require vigorous masticatory activity (Kaidonis et al. 1992:105). Molnar (1971:176) states that the examination of skeletons from the Neolithic period forward reveals that there exist a wide variety of morphological and attritional differences in the dentitions of various human populations. Newman (1974:496), in a study of mastication in living populations, found that human groups that consume "natural" diets are capable of producing more bite force during mastication than their modern counterparts. In another study, Kaifu et al (2003:47) note that the dentitions of prehistoric humans are strikingly different from those of modern human populations. They state that the teeth of hunter-gatherers exhibit heavy wear across the dental arch and that the amounts of wear observed in human populations has decreased since the development of agriculture (Kaifu et al. 2003:47). Wolpoff (1971:206), citing a number of studies involving interproximal wear analysis states that extensive interproximal wear has been observed in the skeletal remains of Australian aborigines, Native Americans, West Africans, and Pacific Islanders thought to rely on hunting and gathering as the key mode of subsistence.

As a result of studies targeted toward the identification of the causes of interproximal wear, its role in human biological and cultural evolution, and the cross-cultural comparisons of different patterns of wear, it is clear that intergroup differences in interproximal wear rates can be studied in order to gain insight into masticatory function and, therefore, diet and other factors related to subsistence. The methods developed for the analysis of interproximal wear differences can thus be used to correlate archaeological and osteological materials in order to develop a better understanding of culture, technology, and subsistence choices among prehistoric groups (Molnar 1971:176).

# CHAPTER 4: ANALYSIS OF INTERPROXIMAL TOOTH WEAR AT THE ABLES CREEK CEMETERY

This research project began in the Fall 2010 with the goal of re-analysis of the Ables Creek skeletal material in order to identify population-level indicators of an infectious disease epidemic. However, because of a variety of issues, the decision was made in Spring 2011 to focus instead on an analysis of interproximal wear at the Ables Creek Cemetery. This chapter begins with a discussion of previous analyses of the Ables Creek skeletal material and problems with the skeletal collection. Next, the research questions and expectations that guided this project will be discussed. Finally, a detailed description of the methods used in this project will be provided.

## A. PREVIOUS ANALYSES OF THE ABLES CREEK SKELETAL MATERIAL

In the Spring of 1993, Moorehead and Tiné began a thorough analysis of the Ables Creek skeletal collection (Tiné 1996:37) with the goal of establishing a demographic profile for the cemetery population and examining the possibility that an epidemic was responsible for the disruption of mortuary patterning at the site (Tiné 1996). Given the long-term use of the Ables Creek cemetery, the large sample size, and the premise that the burial program was disrupted by an increase in mortality as a result of a European epidemic, Tiné and Moorehead first decided to look for a way in which to divide the cemetery population into two distinct and, therefore, comparable groups (Tiné 1996:31).

In 1993, Moorehead created a preliminary demographic analysis of 119 individuals (Tiné 1996:21) who met certain criteria for inclusion in the burial sample using previously established aging and sexing techniques (Tiné 1996:31). Moorhead attempted to divide the cemetery population into two groups based on Jackson's (1992) hypothesis that suggested that the southern portion of the cemetery was the later portion. However, because dividing the cemetery in this way did not provide a clear bimodal demographic profile, Moorhead decided to pursue other means of dividing the cemetery into two groups (Tiné 1996:21). Based on information provided in Jackson's archaeology report, Moorhead decided to pursue the idea that, because the highest status graves were multiple interments, the Ables Creek population could be divided into groups based on whether the individuals belonged to a single interment burial or a multiple interment burial (Tiné 1996:21). After generating mortality curves for each of these groups, Moorhead found that the single interment individuals exhibited what she considered to be an "epidemic type of curve" (Tiné 1996:21). Moorhead concluded that the mortality peak in the adolescent and young adult groups was an indication than an epidemic had affected the single interment group (Tiné 1996:22). Further, she concluded that the Ables Creek population consisted of an epidemic group, represented by the single interments, and a transitional group, the multiple interments, that represented an increase in the Ables Creek population as the assimilated and recovered from the ravages of the epidemic (Tiné 1996:22).

As a result of Moorhead's demographic findings, Tiné's analysis of the Ables Creek skeletal material focuses on the examination of whether or not Moorhead's hypotheses were supported by the skeletal evidence (Tiné 1996:31). Specifically, she hypothesized that "if the multiple interments are representative of the aftermath of a major cultural disruption [such as an epidemic], evidence of decreased quality of diet, increased non-specific stress, and increased biomechanical stress should be present among individuals in multiple burials" (Tiné 1996:32). Tiné's analysis generally supports this hypothesis, but because of notable exceptions (Tiné 1996:99), Tiné concluded that there are real differences in overall stress and health but, because of sample size, the results are "tentative at best and inconclusive at worst" (1996:103).

## B. PROBLEMS WITH THE ABLES CREEK SKELETAL COLLECTION

Any analysis of the Ables Creek skeletal collection is constrained by the condition of the collection itself. As discussed in Chapter 2, extensive pot-hunting and agricultural disturbance at the site and the limited nature of the excavations has led to numerous issues with regard to the Ables Creek skeletal collection.

The limited knowledge and training of volunteers in the field resulted in a lack of uniform data recording, labeling problems, and the intermixing and displacement of some skeletal materials (Tiné 1996:35). Additionally, in the field, pit outlines were unrecognizable and the dense packing and superimposition of burials made identification of specific units difficult. As a result, burial numbers were assigned to skeleton numbers (which had been assigned in the field to each feature containing human bone) in the laboratory, retroactively, based on the drawings done at the site (Jackson 1992:16).

Tiné reports that, when conducting the initial analysis in 1993, skeletal elements belonging to the same individual were often associated with more than one accession or skeletal number (Tiné 1996:37). She also reports that commingled remains were present in nearly every burial and skeletal elements determined to be extraneous were labeled as commingled and excluded from her analysis (Tiné 1996:38).

When reanalysis began in Fall 2010, it was immediately clear that there were major issues with the labeling and identification of individuals in the Ables Creek collection.

Initially, I intended to analyze each individual in numerical order by burial (as listed in Jackson's site report). However, as analysis continued, it became very clear that the labels on boxes and in the bags did not correspond well with either the enclosed skeletal material or the archaeological report. Often, accession and skeleton numbers were encountered that were not listed in any earlier inventory. Additionally, in nearly every burial examined, we recovered elements belonging to previously unrecorded infants.

Given these numerous issues with the Ables Creek skeletal collection, it is not unreasonable to suggest that any further analysis of this material should not rely on correlating the skeletal material as labeled with similarly labeled elements on site maps generated in the field. Because the specific provenience of any skeletal material with in the cemetery has essentially been lost, the Ables Creek skeletal collection should only be examined as an undifferentiated sample.

## C. RESEARCH QUESTIONS

During the analysis of the Ables Creek skeletal collection, it became clear that there was extensive interproximal wear in the dentitions of many individuals, including very young adults. As a result, I made the decision to examine the amount of interproximal tooth wear of individuals from the Ables Creek cemetery compared to that of individuals from the Upper Nodena skeletal collection. The Upper Nodena collection was chosen as a comparative population because of the unequivocal evidence for maize cultivation and consumption recovered at the site.

A review of the literature resulted in the discovery of an article, published in the *American Journal of Physical Anthropology*, that examined skeletal remains from the

Archaic, Woodland, and Mississippian periods on North America with the goal of finding difference in the amount of interproximal wear between hunter-gatherers (Archaic populations), transitional groups (Woodland populations), and populations who depended primarily on maize agriculture (Mississippian) (Hinton 1982:104). Hinton found that the length of interproximal wear facets differed considerably between the groups (1982:108).

Specifically, he found that that the mean interproximal wear among Archaic people was greater than that of Woodland people while the amount of wear among Woodland populations was greater than that of Mississippian populations (Hinton 1982:105-108). He hypothesized, based on his analysis and the knowledge of the factors that contributed to the development of interproximal wear, that the high rate of interproximal wear in Archaic populations was the result of a difficult to chew diet consisting of seeds, nuts, wild plant foods, and small animals (Hinton 1982:113). The relatively low rates of interproximal wear in the Mississippian sample then indicated that they practiced much less heavy chewing likely because of maize technology and improved cooking technologies (Hinton 1982:113).

Given the knowledge that no direct evidence of agriculture has ever been recovered at any Tillar Complex site, including Ables Creek (Rothschild 1983:838), and the evidence, presented in Chapter 3, that the development of intensified agricultural production was less vital to inhabitants of the Lower Mississippi Valley than to the inhabitants of contemporaneous sites to the north (Kidder and Fritz 1993:294), I hypothesize that the amount of interproximal wear at the Ables Creek cemetery will be significantly greater than the amount of interproximal wear at the Upper Nodena site because the inhabitants of the Ables Creek site were relying on wild plant and animal resources instead of maize as the primary source of nutrition.

In order to fully explore the expected differences in diet at these two sites, I will also examine dental decay frequencies observed at each site. Given the extensive research establishing that the adoption of intensive maize agriculture leads to increased caries rates (Rose, et al. 1984, Rose et al. 1991, Turner 1979), I also hypothesize that the caries rates among individuals in the Ables Creek skeletal collection will be significantly lower than those observed by Powell (1983) in the Upper Nodena collection. The complicated relationship between caries rates and tooth wear will also be examined. Finally, this thesis will discuss a number of ecological and cultural factors that could have played key roles in the development of different diets at these two roughly contemporary sites in eastern Arkansas.

**D. METHODS**

***Determining the Ables Creek Sample***

In the Spring of 2010, I was given the opportunity to re-examine the Ables Creek skeletal population with the goal of constructing a more accurate demographic profile of the cemetery population using new aging and sexing techniques. In order to accommodate the analysis of the skeletal material, the collection, which consists of 67 boxes of human remains excavated from the Ables Creek site in 1986, was transferred from the Arkansas Archaeological Survey collections facility to the Bioarchaeology Laboratory housed at the University of Arkansas, Fayetteville. Preliminary examination of the Ables Creek skeletal material began in Fall 2010 and it soon became clear that the archaeological evidence and the nature of the collection could not support the sample being divided into two discrete groups precluding the possibility that demographic analysis would be possible. Having noticed that the interproximal tooth wear in the sample was extreme and worthy of investigation, I devised the research questions described above.

In Spring 2011, myself and other bioarchaeology graduate students at the University of Arkansas examined each individual in the Ables Creek skeletal collection and took an inventory of the teeth associated with each individual. We began our inventory using the skeletal inventory provided in Jackson's 1992 site report, but quickly realized that that this was not the most efficient approach because many of the skeletons listed in the site report were not identified as such in the skeletal collection. Conversely, many of the skeletal elements in the collection were labeled with accession numbers not listed in the archaeological report. As a result, we systematically opened every box and inventoried each tooth in a given box. The teeth present were recorded on an inventory sheet and, in most cases, were listed by the accession number identifying the individual either on the box or the bag in which the skeletal material was contained. In several cases, more than one obvious dentition was assigned to a single accession number. In these cases, individuals were listed as the accession number associated with them and given a specific letter designation (e.g. 86-486-1A).

After the inventory was complete, I decided (following Hinton 1982) to include only adult individuals with the second premolar, the first molar, and the second molar present in at least one quadrant in the study sample. In cases where the dentition was complete or all the teeth were present in more than one quadrant, teeth from the right side of the mouth were chosen for this study.

***Determining the Upper Nodena Sample***

Upon determining the research focus for this project, it was necessary to identify a comparative skeletal collection that was both available for additional measurements and that was known, archaeologically, to have relied heavily on maize agriculture. After conversations with archaeologists at the Arkansas Archaeological Survey, the Survey collections registrar, and the University of Arkansas Museum curator, the Upper Nodena collection seemed most appropriate for this study.

Using the criteria outlined above for the selection of the Ables Creek sample, I consulted the *Standardized Osteological Database* (SOD) which contains osteological data collected for all skeletal collections held by the University of Arkansas Museum and the Arkansas Archaeological Survey and determined which individuals from the Upper Nodena skeletal collection would be analyzed in this study. Permanent teeth were identified according to codes 2-7 in the *Standards for Data Collection from Human Skeletal Remains* (Buikstra and Ubelaker 1994:49) indicating that the teeth are fully developed, in occlusion, and observable. In addition to the requirement of teeth present in each quadrant, only individuals with assessed age and sex were included in the sample.

***Age and Sex Determination***

Age and sex were determined for the individuals in the Ables Creek collection using the methods described in the *Standards for Data Collection from Human Skeletal Remains* (Buikstra and Ubelaker 1994) whenever possible. Because of the poor preservation and fragmentary nature of the Ables Creek collection, it was not always possible to use multiple methods for age and sex determination. Specific techniques used for each individual are listed in the appendix. Additionally, many individuals were represented only by their teeth and, in these cases; age was determined following the *Atlas of Tooth Development and Eruption* (Al Qahtani et al. 2010). Sex determination was not attempted for these individuals. The age and sex determinations made by Powell (1983) and listed in SOD were used for individuals in the Upper Nodena skeletal collection.

***Tooth Size Measurements***

In this project, it was necessary to record overall tooth size in order to determine if different dimensions of facet size are correlated with the size of the tooth on which the facet is located. Previous studies, using traditional mesio-distal and bucco-lingual crown measurements, revealed a positive correlation between facet length and crown breadth, but negative relationship between facet length and tooth diameter (Hinton 1982:108). Measuring maximum diameter of the tooth crowns is the most common form of tooth size measurement (Hillson et al. 2005:413), but because the mesio-distal diameter is strongly affected by the even the slightest amount of interproximal wear (Hinton et al. 2005:415), it was necessary to identify a more appropriate method for measuring teeth.

Measuring tooth size by taking measurements at the cement-enamel junction has a long history in anthropology, but this method is not often employed because no systematic study had tested the reliability of such a method (Hillson et al. 2005:416). However, in 2005, Hillson et al. published the results of a comprehensive study examining the reliability of cervical measurements. They determined that the use of cervical measurements provide similar results to traditional measurements of crown size in relation to the overall size of the tooth (Hillson et al. 2005:425). Further, they provided evidence that the cervical measurements can be recorded with the same level of reliability that the more traditional crown measurements are and concluded that measurement of tooth size at the cervix are acceptable by the "standards normally applied to dental measurements" (Hillson et al. 2005:424). Most importantly, Hillson et al. determined that, because cervical diameters are rarely affected by wear unless the entire crown is nearly gone (2005:416), cervical measurements are more appropriate for the worn teeth that often comprise the majority of archaeological skeletal material (HIllson et al. 2005:425).

As a result of these findings, I chose to take tooth measurements at the cement-enamel junction following the techniques described by Hillson et al. 2005 using the calipers designed especially for taking these measurements. These calipers, commonly referred to as Hillson-Fitzgerald calipers, are six-inch Mitutoyo Digimatic calipers with specially designed points that are thin enough to pass between teeth still in occlusion. These calipers are accurate to .01mm (Hillson et al. 2005:416-417).

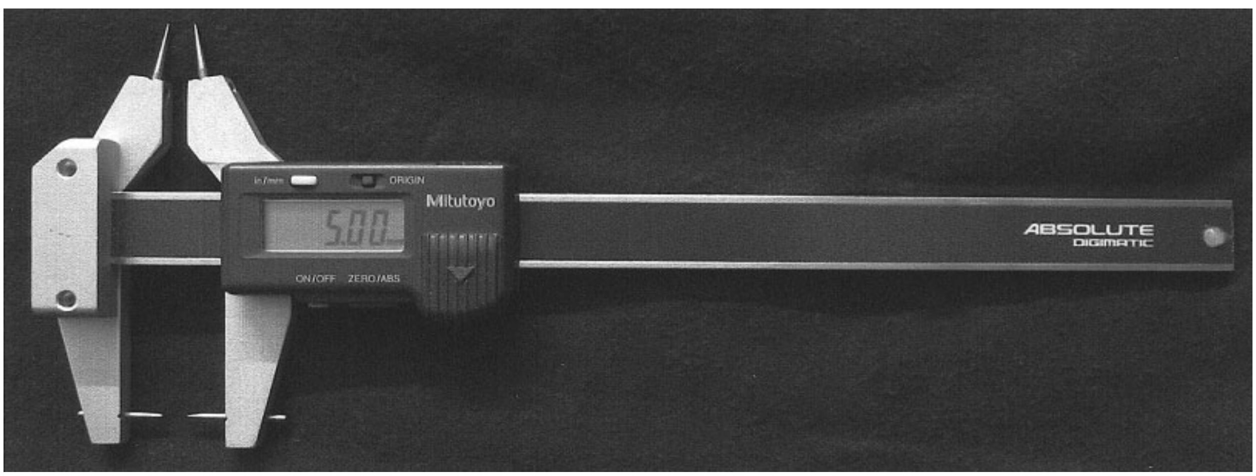


**Figure 4.1: Caliper for cervical measurements used. Image from Hillson et al. 2005:417.**

For all cervical measurements the tips of the caliper points are placed on the enamel surface just occlusal to the cement-enamel junction (Hillson et al. 2005:418) taking care not to allow the tips to rest on the cementum. Mesio-distal cervical diameter in premolars and molars is measured at the midpoint on both the mesial and distal aspects of the crown at the cement-enamel junction (Hillson et al. 2005:418). Bucco-lingual cervical diameter measurements of premolars are taken from the maximum point on the buccal surfaces to the maximum point on the lingual surface along the cement-enamel junction (Hillson et al. 2005:418). Bucco-lingual cervical diameter measurements for the molars are taken along the cement-enamel junction at the mid-point on the buccal and lingual surfaces. The maximum point cannot be used because there are two maximum points on those surfaces in molars (Hillson et al. 2005:418).

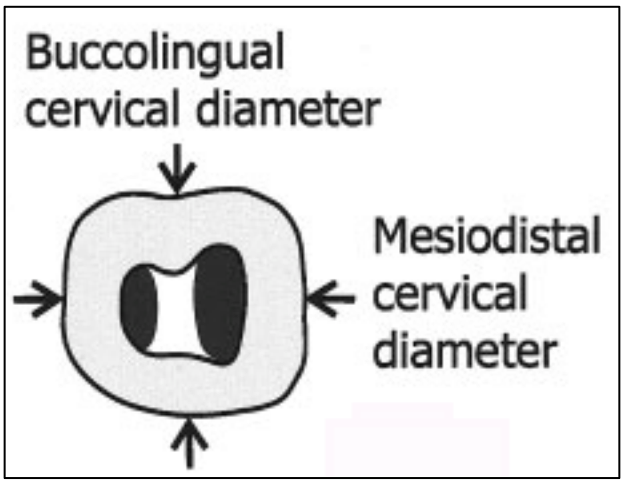


**Figure 4.2: Occlusal view of mandibular molar indicating proper cervical measurement points. From Hillson et al. 2005:415**

***Interproximal Tooth Wear Measurements***

A key component of this research was the development of a more comprehensive method for measuring interproximal wear facets. Previous research involving interproximal wear has generally relied only on a single measurement, facet breadth, to characterize the size of the wear facet even though researchers have recognized that this single measurement cannot account for the interesting shapes of some facets (Hinton 1982:105). After considering a number of possible methods for obtaining more accurate and more descriptive measurements, I decided to take four separate measurements of each interproximal wear facet utilizing digital microscopy. These measurements are only possible if the teeth can be removed from the mandible or maxilla. In some cases, especially with the Upper Nodena skeletal collection, even though the teeth were present, it was impossible to remove them from the jaw because previous researchers had glued them in. In these cases, measurements were taken only on facets that could be properly imaged.

This project examined interproximal wear facets on three teeth: the distal facet on the second premolar, the mesial and distal wear facet on the first molar, and the mesial facet on the second molar. Each facet was imaged using National Stereoscopic Digital Microscope, Model DC4-410 that produces images with 1280x1924 resolution. Measurements were obtained, using the methods described below, using the Motic Images PLUS 2.0 software designed specifically to work with the digital microscope.

In order to ensure measurements were as accurate as possible, careful calibration of the digital microscope and the measurement software was required. According to the manufacturer, proper calibration yields measurements accurate to 0.0001mm. Using the calibration slide provided with the microscope and software package, the user must capture an image of the calibration dot. Following image capture, the image is opened in the Motic Images Plus 2.0 program, appropriate units are selected, and a single measurement line is drawn across the diameter of the calibration dot. Once the measurement generated equals the known diameter of the calibration dot (in this case 2mm), the specific calibration is saved and used for the duration of an imagining session.

To ensure continued accuracy of the measurements, the microscope and software were re-calibrated at the start of each imaging session.

For this project the following measurements were obtained from each interproximal wear facet: facet length, facet height, facet area, and facet perimeter. In order to increase the reliability of these measurements, it was necessary to define standard criteria for each measurement.  All measurements were recorded to the highest level of accuracy possible using the Motic Images PLUS 2.0 software.

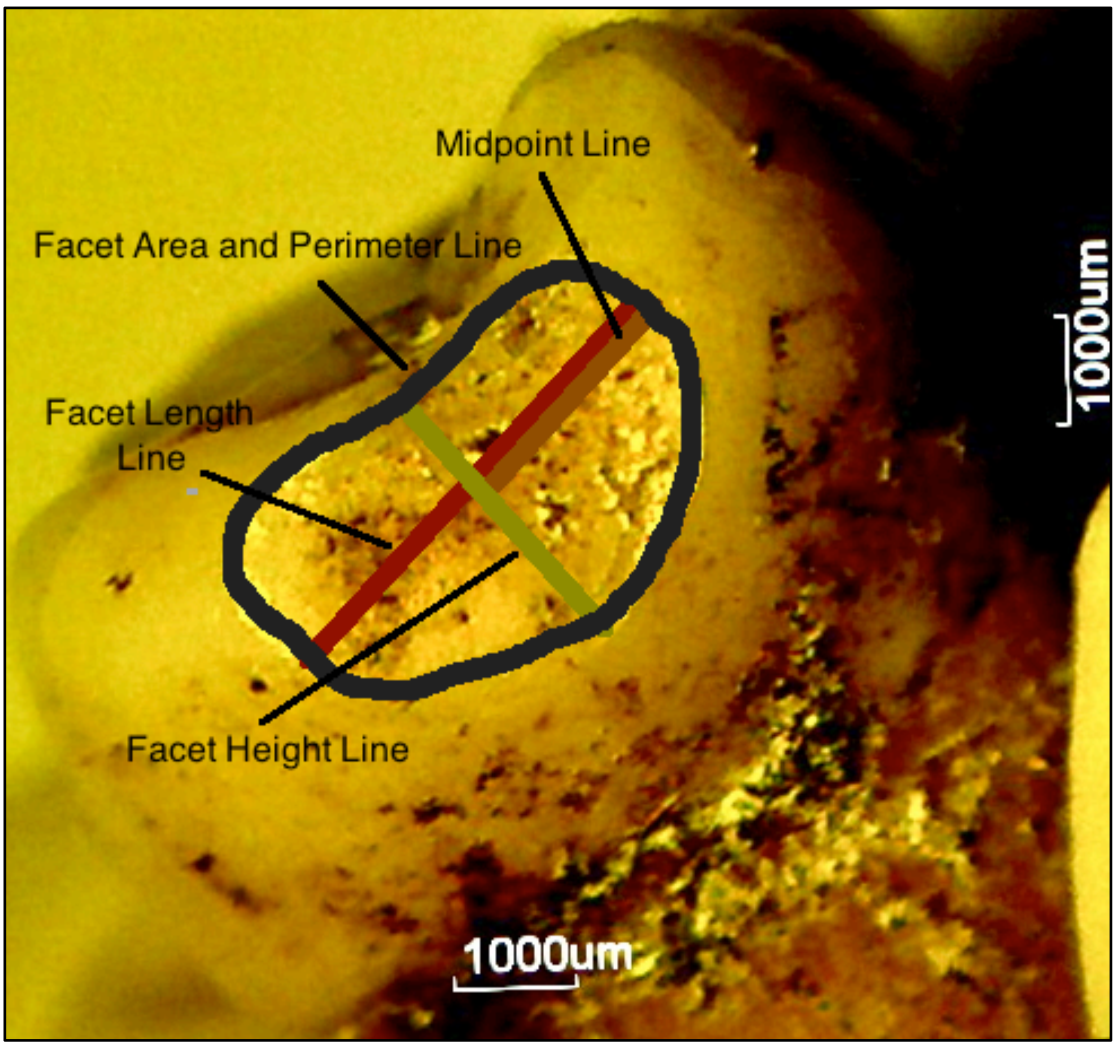


**Figure 4.3: This figure illustrates the specific facet dimension measurements obtained for each tooth: facet length, midpoint, height and perimeter.**

**Facet Length**: Facet length is determined by measuring the maximum length of the facet from the most buccal aspect to the most lingual aspect of the facet.

**Facet Height:** Facet height is determined by measuring the height of the facet at the midpoint of the facet length line. The absolute midpoint is determined by dividing the facet length by two. Because obtaining the absolute midpoint of the facet length line is nearly impossible because of the sensitivity of the measurement software, the midpoint used to record height for each tooth is recorded in the appendix. Generally, the midpoint used is within .001mm of the absolute midpoint of the facet line.

**Facet Area and Facet Perimeter**: Facet area and perimeter are obtained by drawing a free-hand line around the edge of the facet, using a mouse, approximating facet shape as closely as possible. The Motic Images PLUS 2.0 software generated area and perimeter measurements based on this drawn line.

As the method for measuring interproximal wear tooth facets introduced above is newly developed, it was necessary to determine the amount of intra-observer error that occurred when taking these measurements. In order to properly gauge the level of error, all measurements, both tooth size and interproximal wear facet, were re-taken on the first ten sets of teeth (second premolar, first molar, and second molar) from both the maxilla and the mandible approximately four weeks after the original measurements were obtained. The results of the analysis of intra-observer error are reported in the following chapter.

### *Statistical Methods*

All statistical analyses for this project were done using IBM SPSS Statistics 20. For analysis of differences in different dimensions of facet size between the two sites, two-tailed independent sample t-tests were conducted. This test was chosen because it an effective way to compare the means of two groups on a given variable. Because t-tests require the assumption of equal variances, the Levene's Test for Equality of Variance was also conducted prior to each t-test. Analysis of intra-observer error also relied on the above tests, comparing the means for each measurement for each tooth for both sets of data collected.

Analysis of the effects of age and sex on tooth size and interproximal wear facet dimensions was also conducted using two-tailed, independent sample t-tests. Although this author realizes that small sample sizes can have a considerable effect on the results of t-tests, with sample size potentially obscuring differences between the groups, the t-tests provide results useful to this project. Additionally, two-tailed, independent samples t-tests were used to illustrate similarities in overall tooth size between the two sites. For all t-tests, the null hypothesis was that the groups under study were not significantly different and the significance level was $p < 0.5$.

In order to assess the relationship between overall tooth size and facet size and to determine how the different facet measurements correlated with each other, bivariate correlations using the Pearson's correlation coefficient were used. Principal Components Analysis and Discriminant Function Analysis were utilized to assess which facet dimension measurement is most useful for assessing differences in overall interproximal wear facet size between individuals.

# CHAPTER 5: RESULTS

The data collected in this project reveal significant differences in the size of interproximal tooth wear facets and caries rates between the two populations under study, Ables Creek and Upper Nodena. This chapter will report the results of intergroup facet size differences, facet size differences related to age and sex, and will discuss possible explanations for these differences, such as varied social status and ecological stress. Additionally, this chapter will report the differences in caries rates at the two sites and discuss the complicated relationship between tooth wear and caries rates.

## A. TOOTH SIZE

In order to ensure that the two populations under study were comparable, the first step in the analysis was the determination that tooth sizes between the two populations were not so different as to influence the results of later analyses. Hinton (1982:108) reports that bucco-lingual diameter of the tooth crown can serve as a significant, though weak, predictor of facet size. Correlations in this study, however, indicate no significant correlations between tooth size and facet size (for any dimension), but I felt that tooth size differences between the two groups should be reported given the previously reported correlation.

### *Maxillary Teeth*

The mean mesio-distal and bucco-lingual diameters were compared, using a t-test, between the two groups. This analysis shows that there is no significant difference in either mesio-distal diameter or bucco-lingual diameter for any tooth between the two sites (Table 5.1).

**Table 5.1: Maxillary Tooth Measurements**

| | Ables Creek | | | Upper Nodena | | | |
|---|---|---|---|---|---|---|---|
| | n | Mean | SD | n | Mean | SD | p-value |
| P2 | | | | | | | |
| Mesio-distal Diameter | 11 | 4.5955 | 0.3541 | 8 | 4.6150 | 0.3469 | 0.9060 |
| Bucco-lingual Diameter | 11 | 7.9364 | 0.4051 | 8 | 7.9513 | 0.5677 | 0.9470 |
| M1 | | | | | | | |
| Mesio-distal Diameter | 11 | 7.7445 | 0.5259 | 9 | 7.4989 | 0.7015 | 0.3820 |
| Bucco-lingual Diameter | 11 | 10.1291 | 0.7738 | 9 | 10.2956 | 0.6136 | 0.6070 |
| M2 | | | | | | | |
| Mesio-distal Diameter | 12 | 6.8808 | 0.7780 | 4 | 7.2850 | 0.4096 | 0.3440 |
| Bucco-lingual Diameter | 12 | 9.9750 | 1.0912 | 4 | 9.9100 | 0.8144 | 0.9150 |

***Mandibular Teeth***

As with the maxillary teeth, t-test results indicate that there are no significant difference in overall tooth size for any tooth for Ables Creek and Upper Nodena.

**Table 5.2: Mandibular Tooth Measurements**

| | Ables Creek | | | Upper Nodena | | | |
|---|---|---|---|---|---|---|---|
| | n | Mean | SD | n | Mean | SD | p-value |
| P2 | | | | | | | |
| Mesio-distal Diameter | 15 | 4.9433 | 0.3284 | 8 | 5.1763 | 0.5158 | 0.1990 |
| Bucco-lingual Diameter | 15 | 6.5393 | 0.4413 | 8 | 6.8263 | 0.3763 | 0.1340 |
| M1 | | | | | | | |
| Mesio-distal Diameter | 15 | 9.1260 | 0.3560 | 11 | 9.0180 | 0.6513 | 0.5970 |
| Bucco-lingual Diameter | 15 | 8.7467 | 0.6358 | 11 | 8.8340 | 1.0097 | 0.7920 |
| M2 | | | | | | | |
| Mesio-distal Diameter | 15 | 8.6760 | 0.4579 | 15 | 7.0987 | 3.7157 | 0.1140 |
| Bucco-lingual Diameter | 15 | 8.3367 | 0.4640 | 15 | 6.9300 | 3.6184 | 0.1470 |

## B. INTERPROXIMAL WEAR FACET SIZE

Interproximal wear facet measurements were obtained for four different facets on both the maxillary and mandibular teeth. As discussed in Chapter 3, differences in the size of interproximal wear facets are believed to indicate differences in the amount of mastication required to process food. Because of the wide variety of ages represented in the sample, the distal facet of the second molar and mesial facet of the third molar were not included, as several of the youngest adults did not have fully erupted or fully developed third molars.

### *Maxillary Teeth*

Measurements of all facets on the maxillary teeth reveal significant differences between the Ables Creek population and the Upper Nodena population for all dimensions of interproximal wear facet size (length, height, area, and perimeter). For all dimensions, measurements for the Ables Creek population are greater than those of the Upper Nodena population. The specific output of the analysis for each tooth and each measurement is reported in Appendix A. These results are summarized in Figure 5.1.

### *Mandibular Teeth*

Measurements of nearly all facets on the mandibular teeth reveal significant differences between the Ables Creek population and the Upper Nodena population for all dimensions of interproximal wear facet size (length, height, area, and perimeter). The measurements for length on the distal facet of the second mandibular premolar and the mesial facet of the second mandibular molar were not significantly different. However, for all dimensions, measurements for the Ables Creek population are greater than those of the

Upper Nodena population. The specific output of the analysis for each tooth and each measurement is reported in Appendix B. These results are summarized in Figure 5.2.

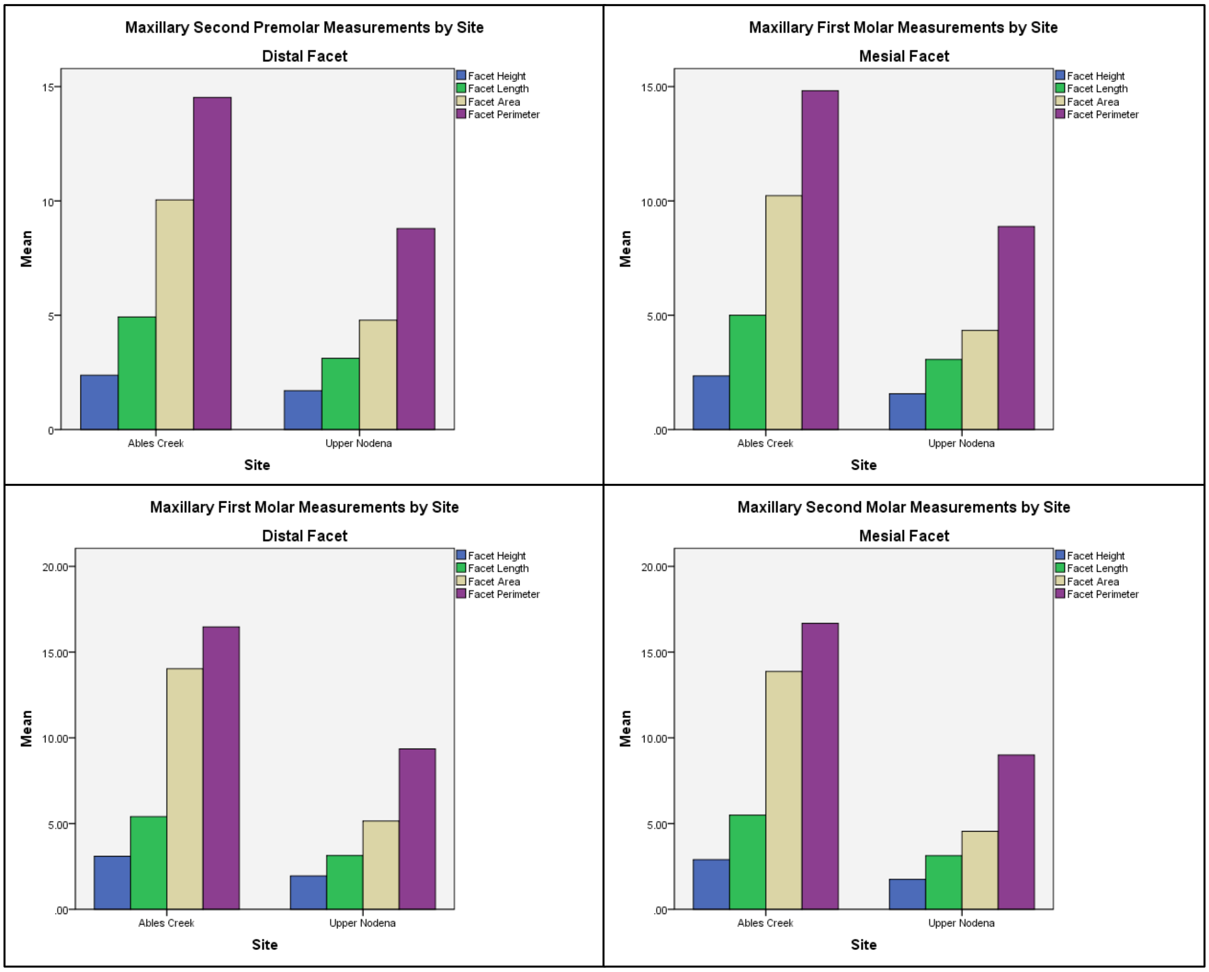


**Figure 5.1: Mean measurements of all maxillary interproximal wear facets by site.**

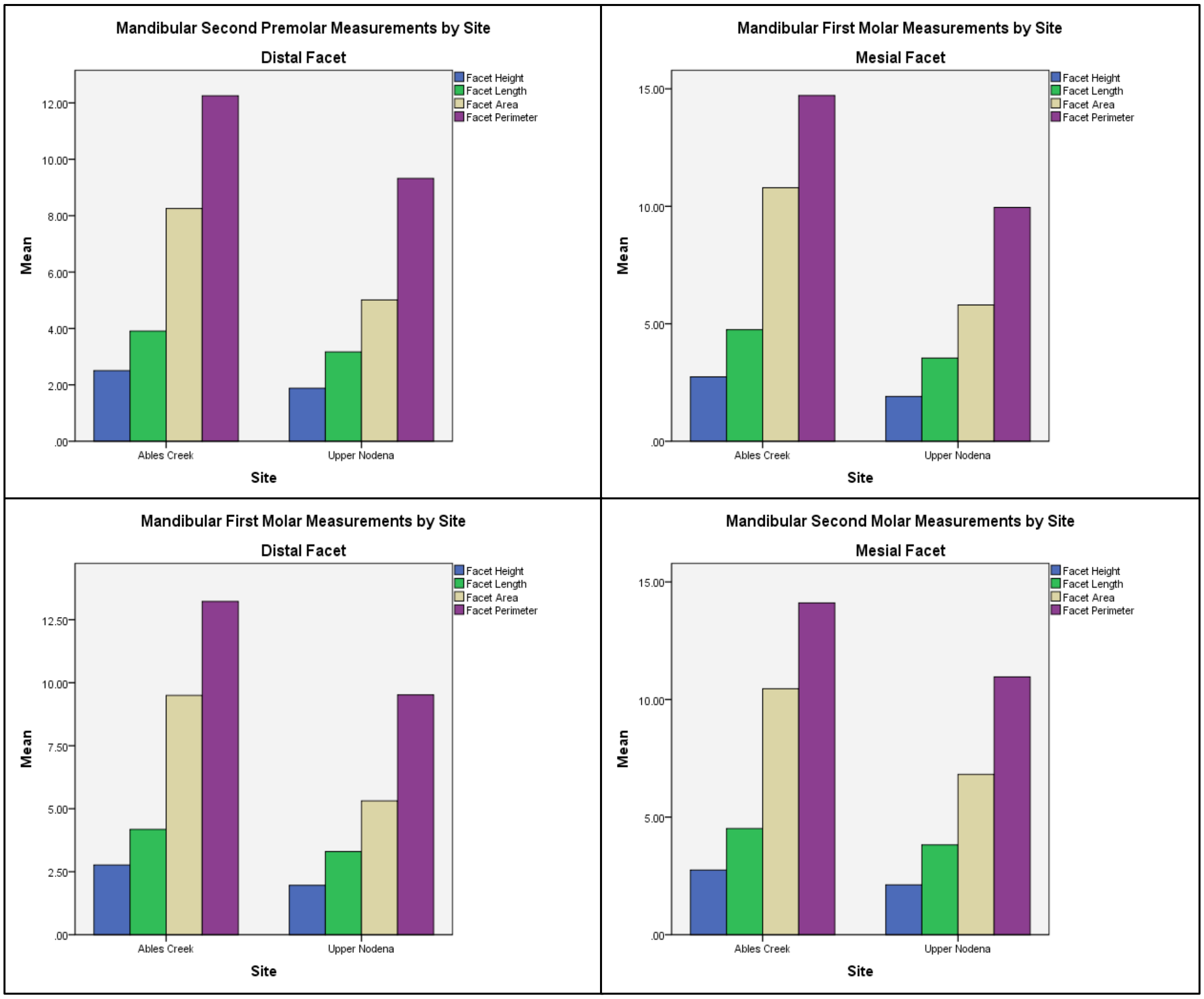


**Figure 5.2: Mean measurements of all mandibular interproximal wear facets by site.**

### *Intra-observer Error*

In order to assess intra-observer error, all measurements of ten sets of teeth from both the maxilla and mandible we re-taken approximately fours weeks after the original measurements were obtained. For both the maxillary and mandibular teeth, there were no significant differences for any measurement, tooth size or facet size, on any teeth. This suggests that the method developed in this project is repeatable.

**Table 5.3: Intra-observer Error Analysis Results**

| | | First Observation | | Second Observation | | |
|---|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD | p-value |
| | ***Maxillary Teeth*** | | | | | |
| **Second Premolar, Distal** | Facet Length | 4.8018 | 0.3811 | 4.9706 | 0.3761 | 0.5520 |
| | Facet Height | 2.3750 | 0.2839 | 2.5053 | 0.2876 | 0.5430 |
| | Facet Area | 9.7250 | 0.6005 | 10.6007 | 1.9167 | 0.4170 |
| | Facet Perimeter | 13.5879 | 1.1936 | 14.8681 | 1.1277 | 0.1700 |
| **First Molar, Mesial** | Facet Length | 4.6094 | 1.2744 | 5.1567 | 0.3300 | 0.5110 |
| | Facet Height | 2.3329 | 0.6047 | 2.6976 | 0.2571 | 0.3910 |
| | Facet Area | 9.5968 | 4.4013 | 11.3772 | 2.3928 | 0.5710 |
| | Facet Perimeter | 13.3765 | 3.2360 | 15.2759 | 1.6502 | 0.4160 |
| **First Molar, Distal** | Facet Length | 5.5104 | 1.1155 | 5.4283 | 1.1307 | 0.9110 |
| | Facet Height | 3.1657 | 0.4901 | 3.0727 | 0.5494 | 0.7850 |
| | Facet Area | 14.9377 | 4.3794 | 14.1281 | 4.8274 | 0.7880 |
| | Facet Perimeter | 16.3049 | 2.8611 | 16.5951 | 3.2451 | 0.9200 |
| **Second Molar, Mesial** | Facet Length | 5.4188 | 0.7242 | 5.6525 | 0.7745 | 0.6350 |
| | Facet Height | 2.9967 | 0.3637 | 3.0518 | 0.3519 | 0.8140 |
| | Facet Area | 13.6172 | 3.0285 | 14.4931 | 3.4198 | 0.6790 |
| | Facet Perimeter | 14.4931 | 2.0011 | 16.8220 | 2.0524 | 0.4610 |
| | ***Mandibular Teeth*** | | | | | |
| **Second Premolar, Distal** | Facet Length | 3.7063 | 0.5121 | 3.9870 | 0.7930 | 0.5250 |
| | Facet Height | 2.4338 | 0.3006 | 2.6558 | 0.3504 | 0.3140 |
| | Facet Area | 7.2974 | 1.0510 | 8.9078 | 3.0293 | 0.2940 |
| | Facet Perimeter | 11.5883 | 1.0795 | 12.5081 | 2.4054 | 0.4580 |
| **First Molar, Mesial** | Facet Length | 4.5483 | 0.4571 | 4.3726 | 0.3934 | 0.5330 |
| | Facet Height | 2.8211 | 0.4732 | 2.6814 | 0.4446 | 0.6430 |
| | Facet Area | 10.8573 | 1.3641 | 10.0300 | 1.9712 | 0.4630 |
| | Facet Perimeter | 13.9986 | 1.3404 | 14.0225 | 1.3572 | 0.9780 |
| **First Molar, Distal** | Facet Length | 3.8173 | 1.0663 | 3.9966 | 0.8245 | 0.7740 |
| | Facet Height | 2.4327 | 0.7209 | 2.7512 | 0.3679 | 0.4050 |
| | Facet Area | 7.8054 | 3.9071 | 8.7553 | 2.6556 | 0.6650 |
| | Facet Perimeter | 11.3283 | 3.3479 | 12.5217 | 1.9503 | 0.5100 |
| **Second Molar, Mesial** | Facet Length | 4.1411 | 0.9935 | 4.2580 | 0.7721 | 0.8410 |
| | Facet Height | 2.6626 | 0.4787 | 2.7215 | 0.3805 | 0.8350 |
| | Facet Area | 9.3729 | 3.7343 | 9.9322 | 3.3252 | 0.8090 |
| | Facet Perimeter | 12.8354 | 3.2350 | 13.5671 | 2.5066 | 0.7000 |

## C. AGE AND SEX DIFFERENCES

As part of data analysis, the overall differences in facet dimensions for people of different ages and different sexes were compared. Because of the limited number of cases with age and sex information, the sample sizes are very small, but some interesting results emerged.

A comparison of both mandibular and maxillary tooth facets for each sex, using t-tests, indicates that there are no significant differences for any dimension of facet size, across the two populations, related to sex. However, the mean size for males in all facet dimensions is consistently higher. This is likely related to overall tooth size. Had these results indicated significant differences, this could have suggested a sexual division of labor that required one sex to do some sort of non-dietary processing leading to increased interproximal wear. The small sample size prohibited any sort of reliable comparisons between men and women at each site.

Comparisons by age were conducted, but because of the limited amount of specific age data and the limited time available for data analysis, only a young adult group and an old adult group (representing members from both populations) were done. Young adult was defined, for the purposes of this project, as individuals aged approximately 15-30 years. Old adults were defined as individuals over the age of 30. These comparisons yielded very interesting results and suggest that further research is required in order to fully understand how interproximal wear develops differently at different contact points and on the upper and lower dental arches.

**Table 5.4: Interproximal Wear and Sex**

| | | Males | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| | | n | Mean | SD | n | Mean | SD | p-value |
| | ***Maxillary Teeth*** | | | | | | | |
| **Second Premolar, Distal** | Facet Length | 1 | 3.5476 | | 8 | 3.1742 | 1.5471 | 0.827 |
| | Facet Height | 1 | 2.2974 | | 8 | 1.6738 | 0.5361 | 0.309 |
| | Facet Area | 1 | 5.8311 | | 8 | 4.8949 | 3.3701 | 0.801 |
| | Facet Perimeter | 1 | 10.1639 | | 8 | 9.1572 | 4.2943 | 0.831 |
| **First Molar, Mesial** | Facet Length | 1 | 3.5476 | | 8 | 3.1742 | 1.5471 | 0.827 |
| | Facet Height | 1 | 2.2974 | | 8 | 1.6738 | 0.5361 | 0.309 |
| | Facet Area | 1 | 5.8311 | | 8 | 4.8949 | 3.3701 | 0.801 |
| | Facet Perimeter | 1 | 10.1639 | | 8 | 9.1572 | 4.2943 | 0.831 |
| **First Molar, Distal** | Facet Length | 1 | 3.4525 | | 8 | 3.4330 | 1.7290 | 0.992 |
| | Facet Height | 1 | 2.0877 | | 8 | 1.6823 | 0.4438 | 0.418 |
| | Facet Area | 1 | 5.5873 | | 8 | 5.5713 | 4.3401 | 0.997 |
| | Facet Perimeter | 1 | 10.0736 | | 8 | 10.0784 | 4.8883 | 0.999 |
| **Second Molar, Mesial** | Facet Length | 1 | 3.4409 | | 8 | 3.4747 | 1.2222 | 0.980 |
| | Facet Height | 1 | 2.1520 | | 8 | 2.1181 | 0.6971 | 0.965 |
| | Facet Area | 1 | 5.9394 | | 8 | 6.3522 | 3.4564 | 0.914 |
| | Facet Perimeter | 1 | 10.1492 | | 8 | 10.5492 | 3.5882 | 0.919 |
| | ***Mandibular Teeth*** | | | | | | | |
| **Second Premolar, Distal** | Facet Length | 2 | 3.7095 | 1.0842 | 8 | 3.2484 | 1.1215 | 0.616 |
| | Facet Height | 2 | 2.5272 | 0.6958 | 8 | 1.9397 | 0.5212 | 0.211 |
| | Facet Area | 2 | 7.5030 | 3.8716 | 8 | 5.2662 | 2.7863 | 0.365 |
| | Facet Perimeter | 2 | 11.2070 | 3.0696 | 8 | 9.7507 | 3.4827 | 0.606 |
| **First Molar, Mesial** | Facet Length | 3 | 3.9581 | 0.8984 | 9 | 4.0458 | 1.2946 | 0.917 |
| | Facet Height | 3 | 2.5596 | 0.2092 | 9 | 1.9237 | 0.5705 | 0.096 |
| | Facet Area | 3 | 8.1954 | 2.0136 | 9 | 6.9095 | 3.5817 | 0.575 |
| | Facet Perimeter | 3 | 12.1168 | 1.3489 | 9 | 10.8916 | 3.8497 | 0.611 |
| **First Molar, Distal** | Facet Length | 2 | 3.8324 | 0.1887 | 9 | 3.2767 | 1.1673 | 0.535 |
| | Facet Height | 2 | 2.1481 | 0.0888 | 9 | 2.0933 | 0.7298 | 0.921 |
| | Facet Area | 2 | 6.8160 | 0.1882 | 9 | 6.0988 | 3.6791 | 0.797 |
| | Facet Perimeter | 3 | 7.3713 | 6.3937 | 11 | 8.3331 | 5.1911 | 0.790 |
| **Second Molar, Mesial** | Facet Length | 3 | 4.2551 | 0.2970 | 10 | 3.8063 | 1.3805 | 0.598 |
| | Facet Height | 3 | 2.2360 | 0.2259 | 10 | 2.2177 | 0.7292 | 0.967 |
| | Facet Area | 3 | 7.7128 | 1.8819 | 10 | 7.3611 | 4.0121 | 0.888 |
| | Facet Perimeter | 3 | 12.2253 | 1.7247 | 10 | 11.2166 | 4.0111 | 0.687 |

Comparisons by age of the maxillary teeth reveal that facet dimensions between the second premolar and first molar are all significantly different for young and old individuals, except for facet height. Facet sizes at the first molar-second molar contact point are not significantly different, for any dimension, between age groups. These results confirm the common sense idea that interproximal wear progresses throughout life (Kaifu et al. 2003:48). The fact that there is no significant difference with regard to age at the first molar-second molar contact point possibly indicate that, because of the relatively late eruption of the second molar, there is less time for interproximal wear forces to create large facets prior to death.

**Table 5.5: Interproximal Wear and Age**

**Maxillary Teeth**

| | | Males | | | Females | | | |
|---|---|---|---|---|---|---|---|---|
| | | n | Mean | SD | n | Mean | SD | p-value |
| **Second Premolar, Distal** | Facet Length | 10 | 3.0613 | 1.2195 | 3 | 5.8202 | 0.5355 | 0.003 |
| | Facet Height | 10 | 1.7963 | 0.5449 | 3 | 2.2173 | 0.2133 | 0.228 |
| | Facet Area | 10 | 4.8149 | 2.0034 | 3 | 11.0338 | 2.0861 | 0.007 |
| | Facet Perimeter | 10 | 8.9551 | 3.6203 | 3 | 16.3334 | 1.8009 | 0.007 |
| **First Molar, Mesial** | Facet Length | 10 | 3.1770 | 1.3611 | 3 | 5.6753 | 0.3435 | 0.001 |
| | Facet Height | 10 | 1.7369 | 0.4294 | 3 | 2.0397 | 0.6996 | 0.368 |
| | Facet Area | 10 | 5.1850 | 3.7317 | 3 | 10.2326 | 3.3570 | 0.060 |
| | Facet Perimeter | 10 | 9.5657 | 4.0515 | 3 | 15.8485 | 1.9870 | 0.028 |
| **First Molar, Distal** | Facet Length | 10 | 3.7082 | 1.2969 | 2 | 4.2913 | 0.6274 | 0.559 |
| | Facet Height | 10 | 2.3844 | 0.8846 | 2 | 2.3358 | 0.1802 | 0.942 |
| | Facet Area | 10 | 7.8930 | 5.0292 | 2 | 7.8543 | 1.4708 | 0.992 |
| | Facet Perimeter | 10 | 11.2958 | 3.9162 | 2 | 12.5738 | 1.9982 | 0.671 |
| **Second Molar, Mesial** | Facet Length | 6 | 4.1357 | 1.0447 | 2 | 5.2302 | 1.0883 | 0.250 |
| | Facet Height | 6 | 2.5238 | 0.8583 | 2 | 2.4470 | 0.3620 | 0.910 |
| | Facet Area | 6 | 9.3309 | 5.1714 | 2 | 11.8079 | 5.1499 | 0.580 |
| | Facet Perimeter | 6 | 12.5927 | 3.7492 | 2 | 15.8029 | 3.7216 | 0.334 |

Comparisons of facet sizes of the mandibular teeth between the two age groups reveal that for all facets, there is no significant difference between facet dimensions. Generally, the older adults had larger facet dimensions than the young adults. These results were somewhat unexpected as I assumed that the forces that cause interproximal wear acted equally on both the upper and lower dental arches. This could be a situation where statistics cannot reveal differences that exist because of small sample size, but further research is required to determine if there are known differences between the development of interproximal wear on the different arches.

**Table 5.6: Interproximal Wear and Age**

**Mandibular Teeth**

| | | Young Adults | | | Old Adults | | | |
|---|---|---|---|---|---|---|---|---|
| | | n | Mean | SD | n | Mean | SD | p-value |
| **Second Premolar, Distal** | Facet Length | 15 | 3.6513 | 1.0134 | 4 | 3.3726 | 0.8198 | 0.621 |
| | Facet Height | 15 | 2.2500 | 0.5998 | 4 | 2.1656 | 0.5645 | 0.804 |
| | Facet Area | 15 | 7.0678 | 3.3573 | 4 | 5.8259 | 2.4985 | 0.503 |
| | Facet Perimeter | 15 | 11.2350 | 3.1923 | 4 | 10.1203 | 2.5852 | 0.531 |
| **First Molar, Mesial** | Facet Length | 17 | 4.2406 | 1.0344 | 4 | 4.1551 | 1.1003 | 0.885 |
| | Facet Height | 17 | 2.3067 | 0.6743 | 4 | 2.3189 | 0.7952 | 0.975 |
| | Facet Area | 17 | 8.4488 | 3.6305 | 4 | 8.1849 | 4.5597 | 0.902 |
| | Facet Perimeter | 17 | 12.4108 | 3.4293 | 4 | 12.5076 | 3.3825 | 0.960 |
| **First Molar, Distal** | Facet Length | 17 | 3.4837 | 0.8993 | 3 | 4.6875 | 1.2908 | 0.058 |
| | Facet Height | 17 | 2.3440 | 0.6990 | 3 | 2.3682 | 0.8139 | 0.957 |
| | Facet Area | 17 | 7.0638 | 3.2259 | 3 | 9.0925 | 4.5880 | 0.354 |
| | Facet Perimeter | 17 | 9.8330 | 4.3652 | 3 | 10.0346 | 7.5723 | 0.942 |
| **Second Molar, Mesial** | Facet Length | 18 | 3.9682 | 1.0408 | 4 | 4.7815 | 1.1752 | 0.181 |
| | Facet Height | 18 | 2.3445 | 0.6031 | 4 | 2.4452 | 0.4596 | 0.758 |
| | Facet Area | 18 | 7.9792 | 3.3205 | 4 | 9.9717 | 3.9113 | 0.304 |
| | Facet Perimeter | 18 | 11.9044 | 3.1674 | 4 | 14.0145 | 3.4453 | 0.248 |

## D. ASSESSING THE MEASUREMENT METHOD

Following data analysis, it was apparent that the four facet measurements were highly correlated suggesting that it might not be necessary to take each of these measurements in order to understand differences between facet size in different individuals or groups. To test whether the measurements were as highly correlated as they appeared, I first did a series of bivariate correlations.

The bivariate correlations revealed that, as suspected, all of the facet dimensions measurements were highly correlated with each other. On the maxilla, correlation scores ranged from 0.758 to 0.989. For all maxillary facets, the area measurement correlated the best with all of the other dimension measurements. On the mandible, correlation scores ranged from 0.657 to 0.975. For all mandibular facets except one, the area measurements correlated the best with all of the other dimension measurements. In one instance, the perimeter measurement correlated best with the other dimension measurements. For both the maxillary and mandibular facets, the height measurement correlated weakest with the other measurements.

In order to further assess which facet dimension measurement best described differences in overall facet size, I performed Principal Components Analysis (PCA) on the measurements for each interproximal wear facet. For all facets, only one component was extracted from the data. Based on component loading scores, the facet area measurement has the highest correlation with the principal component for the majority of the facets. For three facets, the perimeter measurement was most highly correlated. In all cases, the height measurement was least correlated with the principal component.

Finally, I performed Discriminant Function Analysis on the measurements for each interproximal wear facet to further confirm that the area measurement is the best measurement for assessing differences in overall facet size. The results of this analysis indicate that, for the maxillary facets, 100% of the individuals were correctly classified into their group by the area, perimeter and length measurements. For the mandibular facet, 95.7% of individuals were correctly classified into their group by the perimeter measurements, 86.4% by facet area measurement, and 77.3% by length measurement. For both the maxillary and mandibular wear facets, the height measurement was least successful in classifying individuals into their appropriate group.

The results of the Principal Components Analysis and Discriminant Function Analysis suggest that the area and perimeter measurements are most useful for assessing differences in overall interproximal wear facet size between individuals. Using the method I developed for measuring interproximal wear facets, using digital microscopy, the area and perimeter measurements are derived in the same step. Therefore, I suggest obtaining both area and perimeter measurements when analyzing interproximal wear facet size.

**E. CARIES RATES**

Another interesting line of evidence that further supports the hypothesis that the Ables Creek population was not consuming maize as a key component of the diet is the observed caries rates in the populations under study. The relationship between caries rates and tooth wear is a complicated one, but the evidence suggests that increased tooth wear likely prevents both dental caries and periodontal disease because it acts as a cleansing mechanism and reduces the amount of space between the teeth in which plaque may accumulate (Kaifu et al. 2003:55). Studies indicate that eating a natural diet, defined as a low-carbohydrate diet consisting of mostly wild food resources, effectively prevents the build-up of plaque on tooth surfaces (Newman 1974:495). However, even populations with severe tooth wear will experience high caries rates if their diet is also high in carbohydrates (Kaifu et al. 2003:55).

The caries rate for the Ables Creek population was calculated, using raw data reported by Tiné (1996), by dividing the number of observed caries in the total cemetery population by the number of observed dentitions. This yielded an effective caries rate for Ables Creek of 0.96 carious lesions per person. The caries rate for Upper Nodena, as calculated by Powell (1983) using the same method, was 3.9 carious lesions per person. The caries rate for Ables Creek is substantially lower than those observed for any other Late Mississippian sample in the northern portion of the Lower Mississippi Valley (Harmon and Rose1989:327). Based on this evidence, a comparison of the caries rates at Ables Creek and Upper Nodena suggests that the Ables Creek population was consuming more wild food resources and fewer carbohydrates than the Upper Nodena population.

## CHAPTER 6: SUMMARY AND CONCLUSION

As established in Chapter 3, interproximal tooth wear can provide unique insight into the consistency and texture of foods consumed by an individual and reflects the forces of mastication required to process foods within the mouth (Kaifu et al. 2003:49). Caries rates can be used to assess the presence and prevalence of agriculturally derived carbohydrates in prehistoric diets (Rose et al. 1984:394). The significant differences in the sizes of interproximal wear facets and caries rates for Ables Creek and Upper Nodena populations strongly suggest that the diets of these two roughly contemporary groups were substantially different. When compared to the data obtained by Hinton, the amount of interproximal wear in the Ables Creek population lies between the averages for the Woodland and Mississippian populations studied while the amount of interproximal wear for the Upper Nodena population lies well below the Mississippian average (1982:107). Although maize is known to have been widely exploited and incorporated as a major portion of the diet in the southeastern United States during this time period, these results seem to indicate that the population at Ables Creek was not as reliant on maize as the inhabitants of Upper Nodena; perhaps not relying on it at all. There are several possible explanations for the apparent lack of maize consumption at Ables Creek.

The first possible explanation is that the abundance of wild food resources available provided the inhabitants of Ables Creek with adequate and convenient sources of nutrition (Morse and Morse 1983:68). Ables Creek's proximity to the Mississippi and Arkansas River Valleys and easy access to Bayou Bartholomew would seem to indicate that wild plant and animal resources were abundant in the area. As a result, the Ables Creek population might have chosen to exploit these resources rather than invest the time and energy required to cultivate maize. The absence of any direct evidence of agriculture from Ables Creek or any Tillar complex site (Rothschild 1983:838) suggests this is a reasonable possibility.

Another possible explanation is that the individuals interred at the Ables Creek cemetery were of lower social status than others in the Tillar complex. The relatively few secondary burials, the lack of evidence for mound building or charnel houses, and the small number of burials with dense artifact associations suggest that, despite clear inter-site differences in the Tillar complex, the inhabitants of Ables Creek represented a lower social class than individuals interred at other Tillar complex sites. Evidence from other Lower Mississippi Valley sites support the possibility that maize was only consumed by higher status individuals or as a part of certain rituals (Rose et al. 1984:417). If the Ables Creek cemetery population does indeed represent a lower social class than others in the region, it is possible that this low status prohibited them from having access to substantial amounts of maize.

Reconstructions of the drought cycle in Arkansas from 1531-1980 provide another possible explanation for the differences in diet at the two sites. According to this research, the Palmer Drought Severity index values indicate that the period between 1549 AD and 1577 AD was a time of severe drought; most likely the worst drought in Arkansas in the past 450 years (Stahle et al. 1985). A drought this prolonged and this severe would undoubtedly have had tremendous affects on both agriculture and the availability of wild food resources (Burnett and Murray 1993:235). According to Anderson (2001:148), hunting-gatherer populations were very susceptible to climate change, especially when they exploited only a few key resources.

There is substantial evidence that the rise and decline of complex Mississippian societies coincides with climactic changes. The expansion of Mississippian culture from approximately 800 AD to 1300 AD corresponds with a warming period that would have been conducive to agricultural success (Anderson 2001:166). The later Mississippian period aligns roughly with the Little Age Ice, a period of cooler temperatures and drought conditions, that would have hampered agricultural success and led to the increased warfare and later fragmentation of the complex Mississippian societies (Anderson 2001:166). Some researchers think that these climactic conditions probably played a major role in the disappearance of late Mississippian populations, especially in Arkansas (Burnett and Murray 1993:235).

Given the dates ascertained for the occupation of the two sites examined in this study, it is possible to make some assumptions about the role of climate change in cultural, particularly subsistence, practices. The 1450-1600 AD dates for the Ables Creek site (Jackson 1992) suggest that the cemetery was in use both before and during the drought period. If Jackson's hypothesis is correct and the southern portion of the cemetery is the later portion (Jackson 1992:102-103), those individuals interred there would have been suffering the effects of such dramatic climate change. It is possible that at one point, the inhabitants at Ables Creek were successfully cultivating maize but were forced, because of climate change to revert to hunting and gathering to provide the necessary dietary requirements. Whether the Ables Creek population was reliant on maize agriculture or wild food resources, the apparent disruption in mortuary behavior could possibly be the result of these events. Unfortunately, because of the condition of the skeletal collection and associated records, analyses of changes in interproximal wear rates within the site that might further support this idea are not possible.

The calibrated radiocarbon dates generated from corncobs recovered at Upper Nodena indicate occupation from approximately 1490-1601 AD (Mainfort et al. 2007:114). Based on these dates, it is possible that Upper Nodena had already been abandoned at the onset of the drought and, as a result, their subsistence practices were unaffected by this particular episode of extreme climate change.

The three possible explanations provided here for the apparent lack of maize consumption by individuals interred in the Ables Creek cemetery all have their merits and are supported by paleoecological and archaeological evidence. While it is not possible to determine with any certainty which of the above is the most likely explanation, consideration of these explanations does introduce several possible areas in which further research can be done.

Recent publications in bioarchaeology suggest that we must utilize more direct methods for understanding dietary change in prehistoric populations, such as stable isotope analysis (Katzenberg 2012:99). While destructive analysis of the remains of Native Americans is prohibited by many tribes, new techniques are being developed that minimize the amount of material required for analysis and advances in stable isotope technology provide more reliable results than they have in the past (Katzenberg 2012:99). It is possible that research such as this study can provide tribes with evidence compelling enough to encourage consideration of additional analytical techniques.

Another possible avenue for further research would be the examination of human skeletal remains from other Tillar complex sites, using the methods introduced in this thesis, to determine if these remains exhibit patterns of interproximal tooth wear similar to Ables Creek. A skeletal collection, including 28 crania and some postcranial fragments from approximately 58 individuals excavated from the Tillar site, is currently curated at the Smithsonian Institution (Robert Scott, personal communication). Additionally, approximately 20 individuals from the McClendon site are housed at the Arkansas Archaeological Survey in Fayetteville (Lela Donat, personal commumication). Examination of the remains from these other Tillar complex sites could provide evidence that supports or refutes the possibility that the Ables Creek population was of a lower social status than other Tillar complex groups and, therefore, had limited or no access to maize.

Dissertation research being conducted by Robert Scott, Station Assistant at the Arkansas Archaeological Survey station at Arkansas State University, Jonesboro also promises to lead to a better understanding of subsistence in the Tillar complex. As part of this research, Scott hopes to begin additional excavations at known Tillar complex sites with the explicit purpose of uncovering archaeological evidence related specifically to subsistence.

The examination of interproximal tooth wear and caries rates at the Ables Creek and Upper Nodena sites indicates significant differences in diet. The consideration of cultural and ecological factors as possible explanations for these differences reveals that there is a complex relationship between diet, culture, and the environment. Research aimed at understanding these relationships promises to further inform our knowledge of subsistence in the Lower Mississippi Valley during the Late Mississippian-early protohistoric period.

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## APPENDIX A: MAXILLARY INTERPROXIMAL WEAR DATA

Maxillary Second Premolar Measurements
Distal Facet

| | Ables Creek | | | Upper Nodena | | | |
|---|---|---|---|---|---|---|---|
| | n | Mean | SD | n | Mean | SD | p-value |
| Facet Length | 11 | 4.9248 | 1.0119 | 8 | 3.1169 | 1.5333 | 0.006 |
| Facet Height | 11 | 2.3784 | 0.2801 | 8 | 1.7009 | 0.5575 | 0.003 |
| Facet Area | 11 | 10.0471 | 3.035 | 8 | 4.7854 | 3.4753 | 0.003 |
| Facet Perimeter | 11 | 14.5255 | 2.8364 | 8 | 8.7919 | 4.0148 | 0.002 |

Maxillary First Molar Measurements
Mesial Facet

| | Ables Creek | | | Upper Nodena | | | |
|---|---|---|---|---|---|---|---|
| | n | Mean | SD | n | Mean | SD | p-value |
| Facet Length | 10 | 4.9995 | 1.0888 | 9 | 3.0666 | 1.3139 | 0.003 |
| Facet Height | 10 | 2.35 | 0.3823 | 9 | 1.5661 | 0.4144 | 0.001 |
| Facet Area | 10 | 10.2308 | 3.0778 | 9 | 4.3391 | 3.1115 | 0.001 |
| Facet Perimeter | 10 | 14.8223 | 2.9774 | 9 | 8.8833 | 3.4454 | 0.001 |

Maxillary First Molar Measurements
Distal Facet

| | Ables Creek | | | Upper Nodena | | | |
|---|---|---|---|---|---|---|---|
| | n | Mean | SD | n | Mean | SD | p-value |
| Facet Length | 11 | 5.4109 | 0.8517 | 9 | 3.135 | 0.9252 | 0.001 |
| Facet Height | 11 | 3.0983 | 0.5697 | 9 | 1.9476 | 0.6607 | 0.001 |
| Facet Area | 11 | 14.0287 | 3.9867 | 9 | 5.1475 | 2.6189 | 0.001 |
| Facet Perimeter | 11 | 16.4664 | 2.4789 | 9 | 9.3572 | 2.6691 | 0.001 |

Maxillary Second Molar Measurements
Mesial Facet

| | Ables Creek | | | Upper Nodena | | | |
|---|---|---|---|---|---|---|---|
| | n | Mean | SD | n | Mean | SD | p-value |
| Facet Length | 12 | 5.4903 | 0.7181 | 4 | 3.1302 | 0.7416 | 0.001 |
| Facet Height | 12 | 2.8968 | 0.4756 | 4 | 1.7436 | 0.4986 | 0.001 |
| Facet Area | 12 | 13.8713 | 3.201 | 4 | 4.5482 | 2.1029 | 0.001 |
| Facet Perimeter | 12 | 16.6794 | 2.077 | 4 | 8.9997 | 2.0979 | 0.001 |

## APPENDIX B: MANDIBULAR INTERPROXIMAL WEAR DATA

Mandibular Second Premolar Measurements
Distal Facet

| | Ables Creek | | | Upper Nodena | | | |
|---|---|---|---|---|---|---|---|
| | n | Mean | SD | n | Mean | SD | p-value |
| Facet Length | 15 | 3.9089 | 0.7227 | 8 | 3.1694 | 1.1695 | 0.074 |
| Facet Height | 15 | 2.5063 | 0.4149 | 8 | 1.8831 | 0.6272 | 0.009 |
| Facet Area | 15 | 8.2536 | 2.7636 | 8 | 5.0133 | 3.283 | 0.02 |
| Facet Perimeter | 15 | 12.2531 | 2.0394 | 8 | 9.3218 | 3.7321 | 0.023 |

Mandibular First Molar Measurements
Mesial Facet

| | Ables Creek | | | Upper Nodena | | | |
|---|---|---|---|---|---|---|---|
| | n | Mean | SD | n | Mean | SD | p-value |
| Facet Length | 15 | 4.7483 | 0.6117 | 12 | 3.5439 | 0.9196 | 0.001 |
| Facet Height | 15 | 2.7385 | 0.5186 | 12 | 1.9049 | 0.5089 | 0.001 |
| Facet Area | 15 | 10.7911 | 2.8694 | 12 | 5.8018 | 2.3322 | 0.001 |
| Facet Perimeter | 15 | 14.7165 | 1.8018 | 12 | 9.9491 | 2.4093 | 0.001 |

Mandibular First Molar Measurements
Distal Facet

| | Ables Creek | | | Upper Nodena | | | |
|---|---|---|---|---|---|---|---|
| | n | Mean | SD | n | Mean | SD | p-value |
| Facet Length | 15 | 4.1829 | 0.8178 | 10 | 3.2994 | 0.9498 | 0.018 |
| Facet Height | 15 | 2.7696 | 0.4506 | 10 | 1.9592 | 0.5417 | 0.001 |
| Facet Area | 15 | 9.4998 | 2.3841 | 10 | 5.3094 | 2.256 | 0.001 |
| Facet Perimeter | 15 | 13.2247 | 1.9277 | 10 | 6.9803 | 4.7765 | 0.001 |

Mandibular Second Molar Measurements
Mesial Facet

| | Ables Creek | | | Upper Nodena | | | |
|---|---|---|---|---|---|---|---|
| | n | Mean | SD | n | Mean | SD | p-value |
| Facet Length | 15 | 4.517 | 0.7364 | 14 | 3.8208 | 1.1046 | 0.054 |
| Facet Height | 15 | 2.7506 | 0.3282 | 14 | 2.1232 | 0.5588 | 0.001 |
| Facet Area | 15 | 10.4573 | 2.3584 | 14 | 6.8166 | 3.0648 | 0.001 |
| Facet Perimeter | 15 | 14.1096 | 1.8723 | 14 | 10.9638 | 3.1487 | 0.003 |