A COMPARATIVE ANALYSIS OF THE DENTAL HEALTH OF TWO MIDDLE WOODLAND BURIAL POPULATIONS IN THE LOWER ILLINOIS VALLEY

by

Megan Beth Schwalenberg

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The Gibson and Ray sites are located in the lower Illinois Valley and dated to the Middle Woodland period, ca. 50 B.C. – A.D. 400. Through the examination of 48 skeletons from these sites, this study compares the dental health between the two sites in terms of dental pathologies and their potential correlation to either site, sex, age-at-death, or all of these. Information on dental attrition, caries, abscesses, and other dental pathologies was collected from a pre-selected sample of 24 adults from each site, and estimation of sex and age-at-death were established with two age groups: young adults (20-35) and middle-to-old adults ($35\text{-}50^{+}$). Results show that there is no difference between caries rates at the two sites but a slight difference between abscess rates at the two sites. A statistically significant difference ($p<0.05$) was found in abscess and caries rates between the young and middle-to-old adults, while no correlation was found between the sexes. These results suggest there was little to no dietary difference between the sites and that poor dental health was prevalent among middle-to-old adults. Since the individuals from both sites date to the Middle Woodland period, it would be expected to find comparable rates of dental pathologies between the two samples as a result of similar diets. This information provides insight into the dental health of the Middle Woodland people during the transition from hunting-and-gathering to horticulture in the lower Illinois Valley and a baseline that can be utilized by other researchers for comparison to later maize agriculturalists in the region.

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INTRODUCTION

Defining health in a prehistoric population is not as simple as opening up a Merriam-Webster dictionary and copying the definition. The health of people can be culturally modified by the food they eat, the customs in which they participate, and the environment in which they live. Therefore, when comparing the health of skeletal populations, the environment, culture, and time period must be taken into consideration.

In the archaeological record, well preserved human skeletal remains are uncommon due to the chemical composition of bone and its interaction with the environment. Teeth, on the other hand, have a hard outer layer of enamel that protect them from environmental factors and allow for better preservation (Buikstra and Ubelaker 1994). Dentition can provide an incredible amount of data about the health of an individual and collectively about the health of a community or population. Information on diet, diseases present, as well as age-at-death can be gathered through the analysis of teeth (Buikstra and Ubelaker 1994:47).

The Middle Woodland period, ca. 50 B.C. to A.D. 400, in the lower Illinois Valley, had cultures with horticultural subsistence strategy, transitional between hunting-and-gathering and agriculture. Middle Woodland peoples cultivated native starchy seeds and small grains including goosefoot, knotweed, maygrass, and little barley, as well as oily seeds of sunflower and sumpweed. Though not as pronounced as the introduction of maize, the increase in consumption of these starchy seeds and small grains, with higher amounts of carbohydrates than consumed by earlier populations, may have impacted the people's health which can be studied through their teeth.

The Gibson Site (11C5), located in Calhoun County, and the Ray Site (11BR104), located in Brown County, are two examples of Middle Woodland burial sites in the lower Illinois Valley. The Gibson Site is a typical Hopewell mound group while the Ray Site has no superstructure related to the burials (Flotow 1983). The comparison of dental health can allow for insight into the differences and similarities between the two sites with regard to their location on the landscape, burial within or outside mounds, as well as age- and sex-specific dental patterns. This information could also allow for a better understanding of the health of the Middle Woodland people in the lower Illinois Valley and provide a baseline that can be used by other researchers for comparison to later maize agriculturalists in the region.

BACKGROUND

The sample of individuals for this study was drawn from the Gibson site and the Ray site (Figure 1). Both of these sites are located in the lower Illinois Valley and the majority of the burials were identified with the Middle Woodland culture (King et al. 2011; Jason L. King, personal communication 2012).

Figure 1. Map of Illinois with Ray and Gibson sites.
Source: Flotow 2006: Map 1.

Gregory Perino excavated the Gibson mounds in 1969. The mound group consisted of 7 mounds located on a bluff ridge southwest of the village of Kampsville, Illinois. The burials that were recovered from the site ranged from the Archaic, 6000 B.C. to 1000 B.C., to the Late Woodland, ca. A.D. 450 to 700, period, with the majority of the burials representing the Middle Woodland (Asch et al. 1979; Perino 2006). The individuals in the sample analyzed were from mounds 2, 3, and 5 (Figure 2). The shape of the mounds are fairly oval with the largest being mound 5 with a height of 4.5 feet, a width of 53 feet, and 65 feet in length (Perino 2006:437). It is believed that the people who occupied The Buried Gardens of Kampsville site (11C373) used

the Gibson mounds as well as the neighboring Pete Klunk mounds as their burial place (Flotow 1983). Mound 5 showed evidence of prehistoric clearing of skeletal remains from the central log tomb as major skeletal components were found along or on the ramps leading to the tomb (Perino 2006:437-441).

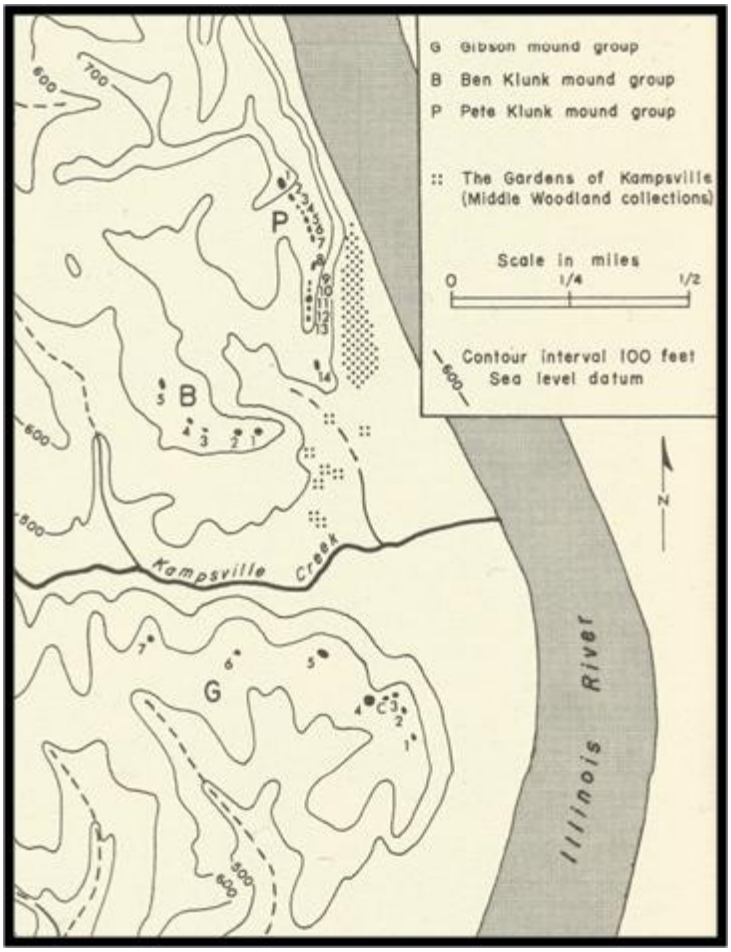

Figure 2. Layout of Gibson mounds.
Source: Buikstra 1976: Figure 2 (modified).

The Ray site is located 60 miles north of the Gibson mounds, near the confluence of the La Moine and Illinois rivers (Figure 3). Glen and Mary Hanning, their family and friends, and other volunteers, both amateur and professional, excavated the Ray site between 1975 and 1980

(Flotow 1983). The Ray site was originally dated to the Middle Woodland period based on the presence of Hopewell artifacts that are associated with the Middle Woodland (Flotow 1983). Through communication with Jason L. King (personal communication 2012) from the Center of American Archeology, I learned that several unpublished calibrated radiocarbon dates on skeletons from the Ray site agreed with the assumption that most of the burials were interred during the Middle Woodland period between ca. 50 B.C. to A.D. 400 (King et al. 2011). There were 112 individuals excavated from the site, and most were in good condition. The ridge where the individuals were buried was historically used as a pasture for cattle, so some of the bones that were close to the surface were damaged due to pasturing (Flotow 2006:25).

This burial site was not typical of Middle Woodland Hopewell culture since it is missing the superstructure that is typical for this time period. The burials at the Ray site were laid out in a linear pattern with most of them being extended parallel to the ridge with the head facing down the slope (Flotow 1983).

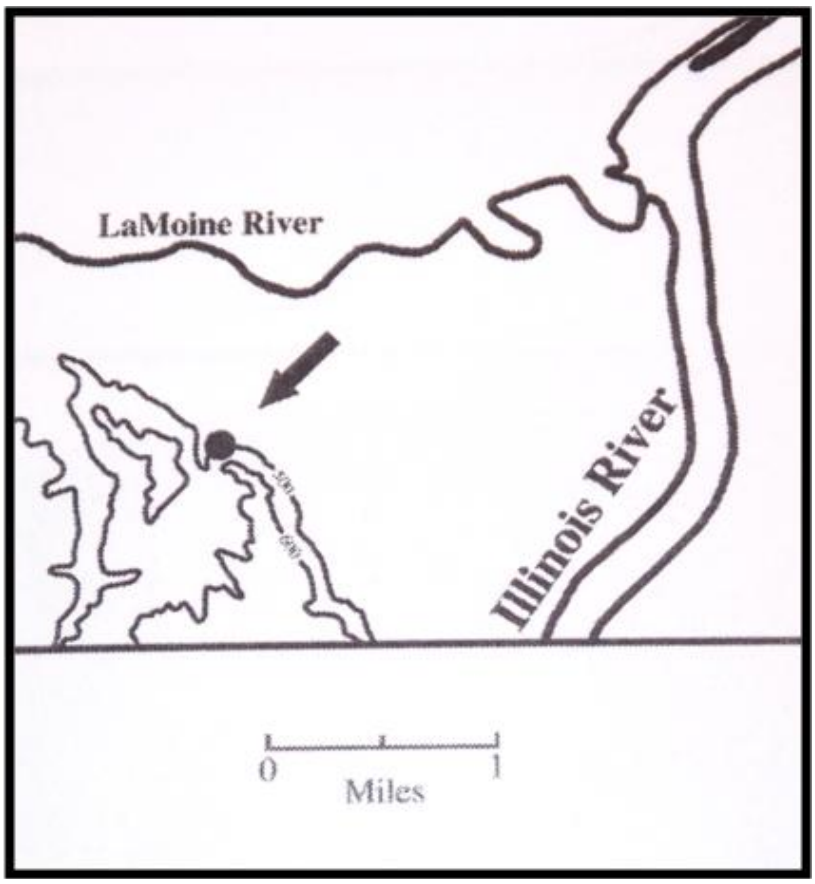

Figure 3. Ray site location along the ridgeline.
Source: Flotow 2006: Figure 2 (modified).

Since this form of burial is so different from the majority of the other Middle Woodland burial sites, Flotow (1983) discusses several hypotheses about the possible reasoning behind a non-mound burial site. One of his hypotheses describes how the Ray site could date to the transitional period between the Middle Woodland and the Late Woodland (Flotow 1983). This hypothesis is interesting because there could be some evidence of this transition period in the dentition, possibly due to the increase in reliance of cereal grains. However, as mentioned above, the unpublished calibrated radiocarbon dates from this site place it solidly within the Middle Woodland time frame, with one date ranging around the transitional time between the Middle Woodland and Late Woodland.

Dentition can provide a vast amount of data about the health of an individual and collectively the health of a community or population. Teeth can provide evidence for diet since the enamel can hold biochemical data, like strontium and carbon isotopes, for many hundreds and thousands of years (Hillson 1996). Information on diet, diseases present, and age-at-death can be gathered through the analysis of teeth (Buikstra and Ubelaker 1994). Since subsistence patterns can greatly affect dental health, a brief look at Middle Woodland subsistence is needed, specifically in the lower Illinois Valley.

Overall, the people of the Middle Woodland period exploited a wide variety of resources from both floral and faunal sources (Asch et al. 1979). The settlement sites that have been discovered on the floodplain would have provided an excellent place to live due to its close proximity to the Illinois River and its tributaries, with its aquatic resources, as well as the forested upland with bigger fauna (Asch et al. 1979). One important resource that had been exploited throughout the Archaic, and well into the Middle Woodland were nuts, such as hazelnuts, hickory, and walnuts (Buikstra 1984). As discussed by Buikstra (1984:224-225), these nuts provided excellent nutritional value to the diet of the Middle Woodland people; however a large population of people could not use nuts as a primary source of nutrients. Faunal remains from different Middle Woodland sites have shown a wide variety both large and small creatures, that were utilized throughout this time period (Flotow 1983). As discussed in Buikstra (1984:217), deer were a very important resource in the area since they provided large quantities of meat. Aquatic resources such as fish and mussel were also utilized since the Illinois River and its tributaries were usually within walking distance of most of the settlements sites (Asch et al. 1979).

One major difference seen in Middle Woodland subsistence patterns in comparison to subsistence patterns of people from the Archaic and Early Woodland was an intensification of cultivation as well as some evidence for domestication of some starchy and oily seeds and small grains (Asch et al. 1979; Smith 2011; Smith et al. 1992). Oily seeds such as sumpweed and sunflower appear to have been domesticated by this period as an increase in seed size is seen in comparison to their wild counterpart (Smith 2011). Other starchy grains such as knotweed, maygrass, and goosefoot were also utilized but were cultivated not domesticated (Buikstra 1984; Smith 2011). The oily seeds provided an excellent source of protein and fat with a small proportion of carbohydrates present (Buikstra 1984; Smith et al. 1992). In comparison, the starchy grains mentioned above contain more protein than maize however; they also contain more carbohydrates than their oily seed counterparts (Buikstra 1984; Smith et al. 1992). The intensification in cultivation of these oily grains, with an increased proportion of carbohydrates, could have affected the overall and dental health of people in a similar way to how people were affected during the transition to maize agriculture, although to a lesser degree.

The increase in the amount of carbohydrates in the Middle Woodland diet could have easily affected the dental health of the people. When carbohydrates are broken down in the mouth, they subdivide into smaller sugars such as sucrose. An elevated amount of sucrose in your mouth can lower the pH, making it more acidic, which allows more cariogenic bacteria to reproduce (Hillson 1996:278). The acids or toxins produced by these bacteria enter into the fissures in teeth and can lead to the destruction of the enamel and dentine, and produce dental caries (Hillson 1996:272-276). The importance of dental caries is discussed in Cassidy's (1972) dissertation where she noted that diets high in carbohydrates and lacking coarse ingredients can lead to an increase in the caries rate. Since the two populations are from a similar time period, it

would be expected that the sites would have similar caries rates as it would be assumed their diets and subsistence patterns were of a similar nature.

METHODS

For the study, I decided to look at males and females from the Gibson and Ray sites, and subdivided the sexes into the age categories of young adults, ages 20–35 and middle to older adults, 35–50+. These categories were chosen in order to observe patterns in dental health across the adult population at both sites. The pre-selected sample analyzed consisted of 48 individuals, 24 from the Gibson Site and 24 from the Ray Site.

In order to place the individuals into their respective demographic categories, sex and age-at-death for each individual was estimated. The methods utilized for estimating sex were the analysis of specific morphological features on the pelvis and skull of the individual as described in Buikstra and Ubelaker (1994). The subpubic region, greater sciatic notch, and the preauricular sulcus were examined on the pelvis, while the nuchal crest, mastoid process, supraorbital ridge, supraorbital margin, and mental eminence were evaluated on the skull (Figures 4 and 5). These features were scored on various number scales with one end being distinctively male, the other being distinctively female, with ambiguous or undeterminable, in the middle of the scale. The pelvis is diagnostic with regard to differences in adult males and females since female pelves are usually shaped to allow for birthing offspring. However, some of these features can be altered from disease or body size (Buikstra 2012b). The features on the skull can be somewhat diagnostic since some features are enhanced by muscle attachments and males tend to have more muscle mass, even around their skull. Even though these features can be very useful in

estimating the sex of an individual, there are some biases that can occur. An example would be the different feature score due to inter- versus intra-observer error.

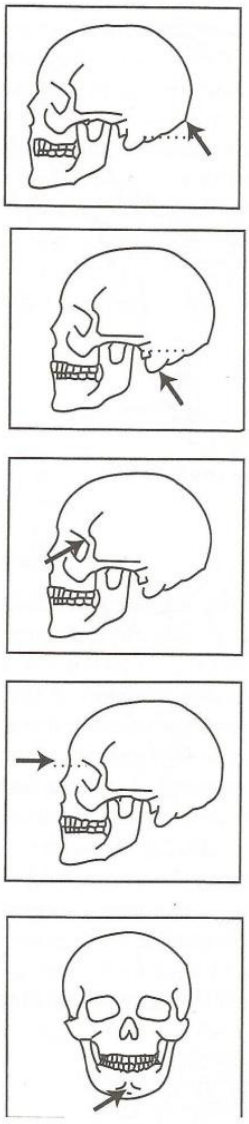

Figure 4. Cranial features utilized in sex estimation. Features from top to bottom: nuchal crest, mastoid process, supra-orbital margin, supra-orbital ridge/margin, and mental eminence. *Source*: Buikstra and Ubelaker 1994: Figure 4.

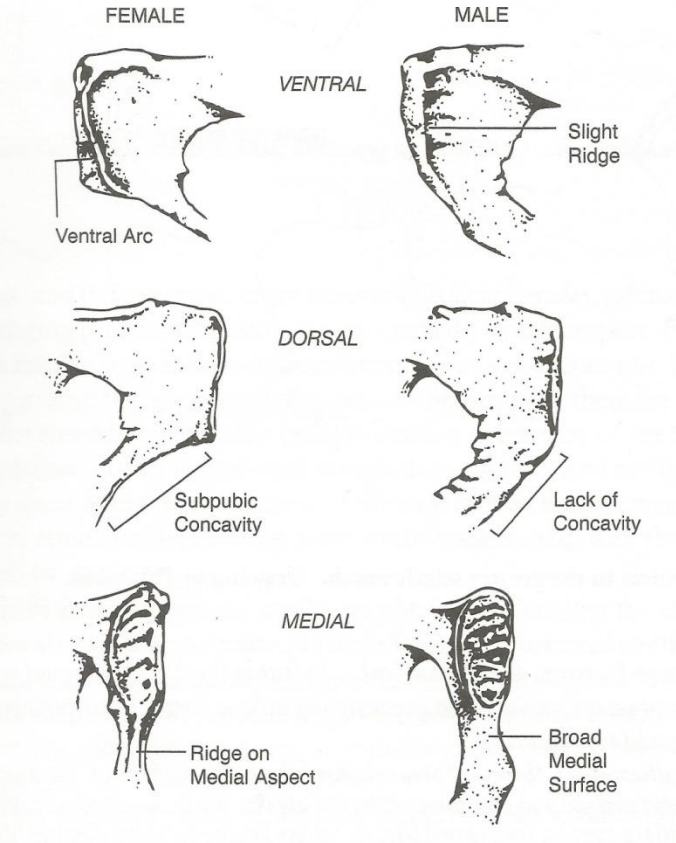

Figure 5. Subpubic features utilized for sex estimation.
Source: Buikstra and Ubelaker 1994: Figure 1.

Estimating age-at-death was completed using several techniques that examined the features of the pubic symphysis, auricular surface of the ilium, and the cranial sutures. The first feature observed was the pubic symphysis, which was scored using two different methods, the Todd and the Suchey-Brooks standards, as described by Buikstra and Ubelaker (1994:22-24). The pubic symphysis, as mentioned by Buikstra and Ubelaker (1994:21), is the most reliable attribute to estimate adult human age-at-death. The Todd Pubic Symphysis Scoring System is based on 10 phases and is not sex specific. The Todd standards encompasses an age range from approximately 18–50 + and is based on the morphological changes of the pubic symphysis. Each phase has a distinct set of characteristics that measure different aspects of the pubic symphysis

such as the ventral and dorsal margin and the shape of the symphyseal face. The pubic symphysis is compared to these descriptive phases and either a phase or a range of phases is scored. The sample population for this method was Caucasian males and females, which could cause some error since the sample in this study contains both males and females from a Native American population (Buikstra 2012a; Garvin et al. 2012). The other pubic symphysis standard, Suchey-Brooks Pubic Symphysis Scoring System, is based on 6 phases and is sex specific only on the photographic comparisons, not the written description (Figure 6). As mentioned previously, each phase has a specific set of characteristics based on the morphological features of the pubic symphysis. Since the Suchey-Brooks standard has only 6 phases, each phase contains more characteristics and therefore encompasses a wider age range. The sample population for this system was based off individuals from the coroner's office in Los Angeles, California (Buikstra 2012a; Wärmländer and Sholts 2011). This sample accounts for differences between the sexes for the pubic symphysis but is a very different population from the sample being analyzed. Though the observation of the pubic symphysis is the most reliable, non-invasive method to estimate adult age-at-death, the standards for comparing them can be somewhat subjective since the characteristics of one pubic symphysis could be found in several phases.

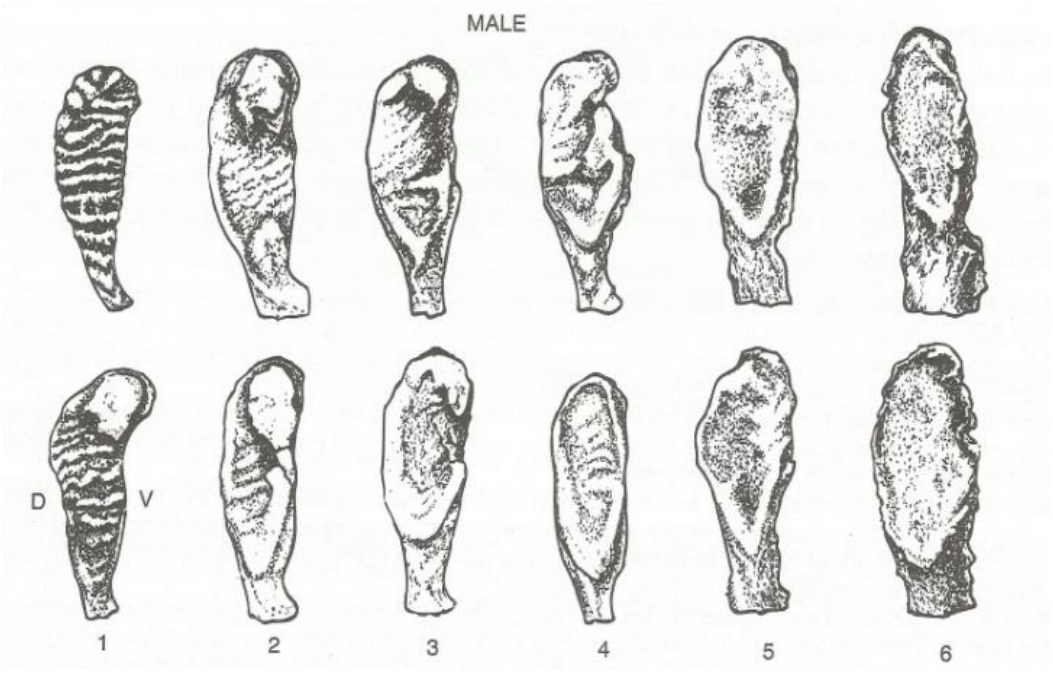

Figure 6. Suchey-Brooks standards for morphological changes in male pubic symphysis. *Source*: Buikstra and Ubelaker 1994: Figure 8.

The next feature observed was the auricular surface of the ilium. Though the auricular surface may not be as accurate in estimating age-at-death as the pubic symphysis, it usually preserves better in the archaeological record (Buikstra and Ubelaker 1994:24). The method used to score the auricular surface is based on the technique by Meindl and Lovejoy described in Buikstra and Ubelaker (1994). This technique has 8 phases and an estimated age range from 20–60 +. These phases are based on surface morphology, texture, and activity in the retroauricular area (Figure 7). The auricular surface is compared to these written standards, and photograph examples, resulting in a phase or range of phases to be assigned.

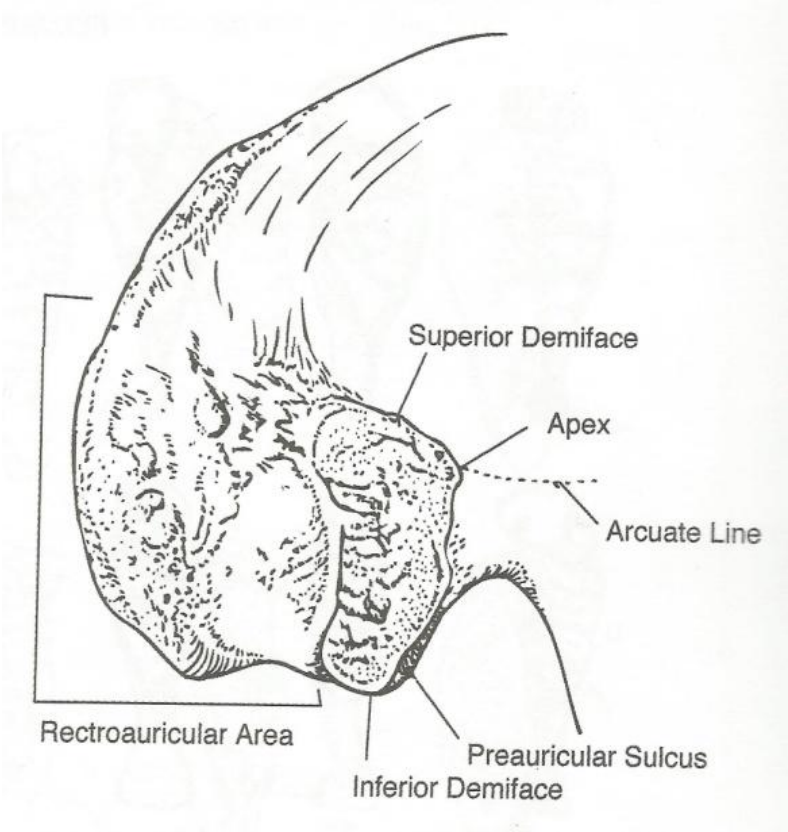

Figure 7. Auricular surface on ilium used for age-at-death estimations.
Source: Buikstra and Ubelaker 1994: Figure 9.

The third feature scored for age-at-death estimation was cranial suture closure. Sutures that were observed included 13 external and internal cranial vault sutures and 4 palate sutures. The scoring of each suture was recorded using the technique by Meindl and Lovejoy, as mentioned by Buikstra and Ubelaker (1994:32). Then the numbers for specific sutures were summed together to give two composite scores, one for the vault sutures, which included 7 vault sutures, and the other for lateral-anterior sutures, of which 5 were utilized. The accuracy of the lateral-anterior sutures, discussed in Buikstra and Ubelaker (1994:36), is a better estimation of age than the vault sutures. This method scored the sutures as open, closed, or in the process of closing. Both endo- and ecto-cranial suture closures can be variable but usually fusion increases

with age, though this variation can decrease the reliability of suture closure for estimation of age-at-death as discussed by Buikstra and Ubelaker (1994:36). For individuals that only had a cranium present, this technique had to be utilized as the final estimation for age-at-death.

Since only non-invasive techniques were used, as much observational data was collected as possible using the methods outlined by Buikstra and Ubelaker (1994) in chapter 5 of *Standards for Data Collection from Human Skeletal Remains*. First, a dental inventory was completed to note the presence or absence of all the permanent dentition. This inventory was scored using a numerical system from 1–8, with each number describing various states of absence, alveolar resorption, and presence, such as in occlusion and not in occlusion, for each tooth. Next, occlusal surface wear of the teeth present were scored using different scoring systems for incisors, canines, and premolars and molars as described by Buikstra and Ubelaker (1994). The incisors, canines, and premolars were scored using the Murphy system, modified by Smith (1984), as discussed in Buikstra and Ubelaker (1994:52). For molars, the Scott system, developed by Scott in 1979, was utilized where the molar is divided into four quadrants and scored for wear individually on a scale from 1, no wear, to 10, no enamel present on the quadrant. The four scores are then summed together to tabulate a final wear score for the molar (Buikstra and Ubelaker 1994:52-53). This method is preferred over the Murphy system, modified by Smith, due to a poor determination of wear on molars with little attrition (Buikstra and Ubelaker 1994:52).

The next category that was observed was the presence or absence of dental caries. Dental caries are caused by decalcification of the enamel or dentine and can appear in the dentition in varying degrees from an opaque area to total tooth destruction (Hillson 1996) (Figure 8). Dental caries were scored using the system developed by Moore and Corbett (1971) and modified by

Buikstra and Ubelaker (1994:55). The different numbers represent the area of origin of the carious lesion such as the occlusal surface or the root. Caries that are too large to estimate the area of origin were scored with a "6".

Abscesses are caused by bacteria that disintegrate tissue around the root of the tooth, and are characterized by a cavity in the alveolar process (White 2012) (Figure 8). Abscesses were noted when they appeared on either the maxillary or mandibular surfaces with a "1" for one located on the labial or buccal portion and a "2" for one located on the lingual surface (Buikstra and Ubelaker 1994:55).

Figure 8. Dental caries and abscess present on lower right first molar.
Source: White 2012: Figure 19.17.

The next feature scored was dental calculus, or mineralized plaque (Figure 9). The presence of calculus was noted on a particular tooth by scoring the amount of calculus, 1–3, and

recording the location of the calculus on the tooth surface, as described by Buikstra and Ubelaker (1994). The analysis of calculus can provide direct evidence of the individual's diet since food remains can become caught in the plaque prior to calcification (Buikstra and Ubelaker 1994; White 2012).

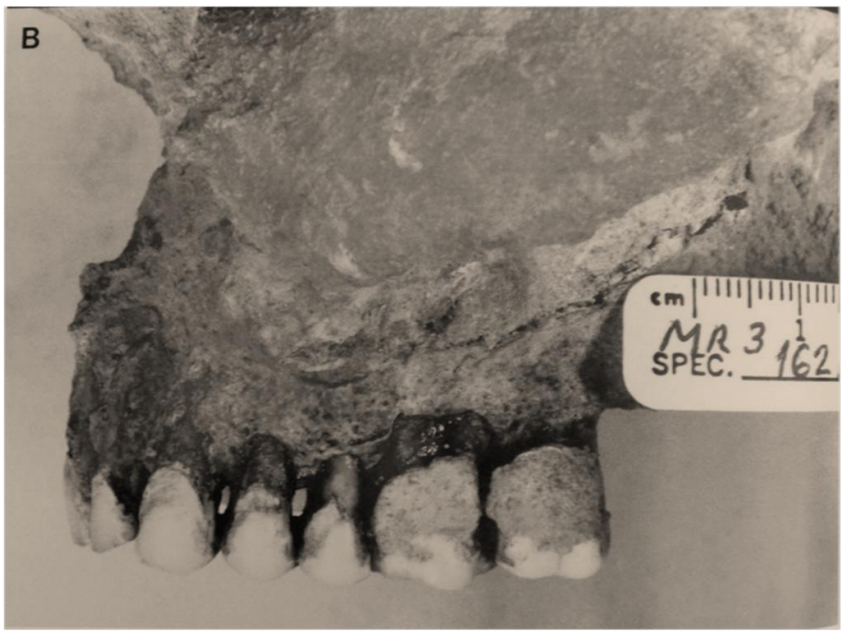

Figure 9. Molars that exhibit dental calculus
Source: Lukas 1989: Figure 4b.

The presence of hypoplasias on a tooth suggests that some trauma occurred during the laying of enamel during development (Hillson 1996:165-166) (Figure 10). Hypoplasias, if present, were scored using the key in Buikstra and Ubelaker (1994:56) which describes the type of disruption, such as horizontal or vertical grooves and pits, seen on the tooth. A measurement can be taken from each line or disruption to the cemento-enamel junction. These measurements can then be compared to a standards table to determine the age at which the trauma occurred (Buikstra and Ubelaker 1994:57). Hypoplasias were only measured in 6 of the 11 individuals

that exhibited them due to time constraints. Opacities, also known as hypocalcifications, were also observed and noted, as described in Buikstra and Ubelaker (1994), on the recording sheet.

Figure 10. Enamel hypoplasias on incisors.
Source: Lukacs 1989: Figure 3a.

In order to compare the dental pathologies t-tests were performed. The teeth were divided into each tooth type and position, i.e. upper 3rd molar, and caries rates were compared across sites, sexes, and age-at-death. Abscess rates were compared as averages per individual. Occlusal wear was averaged per tooth type, i.e. incisors, and compared across tooth type. Measurements of the enamel hypoplasias were used to calculate the age at which the formation of the hypoplasias occurred using the table with the linear regression equation found in Goodman and Rose (1990).

RESULTS

The total number of teeth analyzed was 972, represented by 442 teeth from the Ray site and 530 teeth from the Gibson site. A summary of the data from the Ray and Gibson site are found in Tables 1 and 2 respectively. Question marks represent individuals that had ambiguous features or skeletal elements absent for estimating either sex or age-at-death. I did not include calculus on these tables since I feel that calculus can be affected by preservation both in and out of the ground. Since calculus can sometimes resemble dirt, during the recovery of these teeth some calculus could have been removed and therefore the remaining calculus would give biased results. However, the observation of calculus is important because it can be removed and chemical and isotope tests can be performed to possibly see what types of flora and fauna the people were eating (Buikstra and Ubelaker 1994:56).

Table 1. General Information on Individuals from the Ray Site.

Site/Burial	Sex	Age Range	Total Teeth	Total Caries	Total Abscesses	Hypoplasias
Ray 1-29	Male	35-50	9	0	2	
Ray 1-30	Male	20-35	29	3	2	YES
Ray 1-31	Male	20-35	30	1	0	YES
Ray 1-32	Female	35-50	20	0	0	
Ray 1-52	Female	20-35	30	1	0	YES
Ray 1-54	Male	35-50	30	1	5	
Ray 1-60	Male	35-50	6	5	1	
Ray 1-63	Male	35-50	9	1	13	
Ray 2-6	Male	35-50??	9	3	1	
Ray 2-9	Female	?	1	0	1	
Ray 2-57	Female	35-50	2	0	0	
Ray 2-74	Female	35-50	16	5	5	
Ray 2-82	Female	35-50	17	4	9	
Ray 2-83	Male	35-50	19	7	6	YES
Ray 3-19	Male	35-50	27	10	1	
Ray 3-36	Female	35-50	11	4	8	
Ray 3-37	Male	35-50	26	0	0	
Ray 3-39	Female	20-35	21	2	1	YES
Ray 3-43	Female	35-50	27	11	6	
Ray 3-48	Female	35-50	17	0	4	
Ray 4-21	Male	35-50	25	4	11	
Ray 4-66	Male	20-35	29	0	0	
Ray 5-23	Male	20-35	29	9	0	YES
Ray 6-27	Female	20-35	3	3	0	
TOTAL			442	74	76	6

Table 2. General Information on Individuals from the Gibson Site.

Site/Burial	Sex	Age Range	Total Teeth	Total Caries	Total Abscesses	Hypoplasias
Gibson 2-3	Female	35-50	17	5	6	YES
Gibson 2-4	Female	20-35	27	0	0	YES
Gibson 2-7	Male?	20-35	29	1	0	
Gibson 2-11	Male	20-35	30	2	1	
Gibson 2-13	Female	20-35	31	0	0	YES
Gibson 2-22	Male	35-50	1	0	0	
Gibson 2-25	Female	20-35	32	0	0	
Gibson 2-27	Male	20-35	32	0	0	
Gibson 2-38	Male	20-35	29	1	0	
Gibson 2-49	Can't be Determined	< 20	31	0	0	YES
Gibson 3-5	Female	20-35	31	3	0	
Gibson 3-6	Female	35-50	22	6	2	
Gibson 3-8	Male	35-50	27	24	13	
Gibson 3-9	Male	35-50	29	0	0	
Gibson 3-11	Female??	20-35	3	0	0	
Gibson 3-28	Female	35-50	18	2	6	
Gibson 5-2	Male	35-50	29	2	0	YES
Gibson 5-7	Female	35-50	5	6	0	
Gibson 5-8	Female??	?	22	4	3	
Gibson 5-12	Female	35-50	19	14	6	
Gibson 5-14	Male	35-50	4	1	2	
Gibson 5-23	Male	20-35	32	5	3	
Gibson 5-24	Female	20-35	30	4	0	
Gibson 5-28	Male	?	0	0	0	
TOTAL			530	80	42	5

My assumption of a similar caries rate between the two sites appears to be accurate. The percent of teeth with caries at the Gibson site was 15.1%, while the Ray Site had 16.7% teeth with caries as seen in Table 3. This was calculated by summing the total number of caries present at the respective site and dividing it by the total number of teeth observed. An average of the individuals' caries rate from each site was also compared with the Gibson site being 21.3% and the Ray site being 18.9%.

Table 3. Percent Teeth with Caries by Site.

Site	Total Teeth	Total Caries	Percent Teeth with Caries
Gibson	530	80	15.09%
Ray	442	74	16.74%

I compared the frequency of teeth with caries with regard to young adults, 20–35 years of age, from both the Gibson and the Ray sites versus middle to-old adults, 35–50 + years of age. The individuals were placed into their respective categories based on the estimated age-at-death range that I evaluated for each. The average percent of caries in the young individuals (n=19) is 11.0% while the middle-to-old individuals (n=24) had an average percent of caries of 29.2%, which is significantly ($p<0.05$) from the rate in younger individuals.

When the frequency of teeth with caries was compared based on the sex of the individual, a p-value = 0.37 was found. The males (n=24) had a caries rate of 17.3% while the females (n=21) had an average caries rate of 25.2%. Although these results are not statistically significant at $p<0.05$, the caries rates do show the pattern of higher rates in females. Cassidy (1972) mentions that females tend to have greater caries rates than men, with the reasoning that females' permanent teeth erupt slightly earlier than males (112). In a more recent study, Lukacs and Largaespada (2006) discuss the complicated nature of explaining this phenomenon. Though the differences in caries rates between males and females have usually been explained by cultural practices, the physiological aspects of the human body, for example the fluctuation of hormones during pregnancy, also play a major role (Lukacs and Largaespada 2006:551). When divided first by sex and then by site, the Gibson site shows the most difference in caries rates with males (n=11) having a caries rate of 13.6% while the females (n=10) have an average caries rate of 28.4%.

Cassidy (1972) compared the percentage of teeth with caries by individual tooth type, i.e. mandibular 3rd molars between two populations. This is a better comparison between populations since teeth such as molars with more occlusal surface are more prone to caries than teeth with little occlusal surfaces like incisors (Buikstra and Ubelaker 1994:54). In addition, the percent of teeth with caries can be an over-estimation since some teeth had more than one carious lesion present. When comparing caries rate in this way, I totaled all of a particular tooth present, upper 3rd molar, and counted the number of teeth with a carious lesion present to calculate a percentage. High rates of caries in the molars compared to other tooth types were noted. By comparing the caries rates based on sex, for example comparing Gibson male to Gibson females, most of the teeth types had similar rates. Overall, females showed higher rates in upper 3rd and 1st molars as well as lower canines while males showed higher rates in lower 3rd and 2nd molars (Figure 11). All of these patterns are seen when an intra-site comparison is done between the sexes.

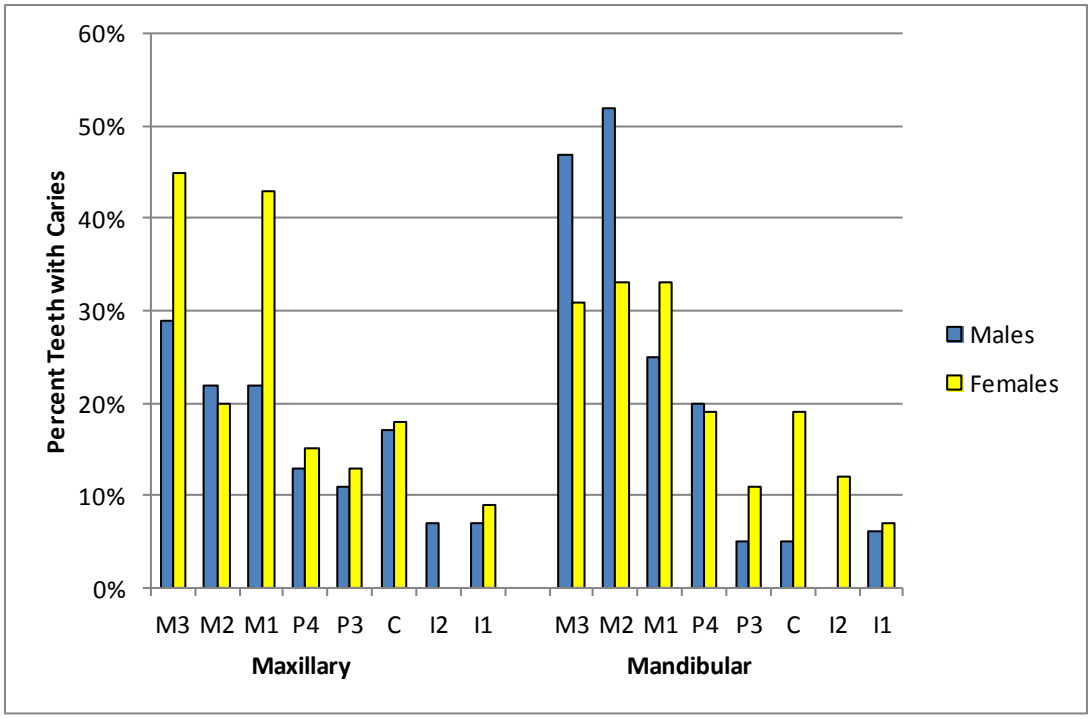

Figure 11. Percent of Caries by Tooth Type between Males and Females.

When comparing by age-at-death, a major difference in caries rates can be seen between young adults and middle to old adults (Figure 12). The older individuals have higher rates of caries in all tooth types compared to young adults. However, upper 3rd molars, lower 2nd molars, and upper 1st incisors in young adults appear to have more similar rates of caries to older individuals. When further divided by site, high caries rates are seen in most of the molars, specifically in lower 2nd molars, of young adults at the Ray site. This pattern could be caused by a larger number of individuals from the Ray site that are considered middle to old (n=15) compared to the young adults (n=7).

When observing the Gibson site's pattern on age, in all categories except upper 1st incisors, caries rates are higher in middle to old adults. The lower molars of the middle to old adults all had caries rates of over 50 percent. When the young individuals were compared by

site, most caries were found in molars, with only three caries found in non-molar teeth. In the four tooth categories where caries were found at both sites, the Ray site always had a higher caries rate. The most noticeable pattern when comparing the caries rate of the middle to old adults from both sites was that the Gibson individuals had much higher caries rates in their mandibular teeth compared to those at the Ray site (Figure 13). This again could be due to a higher sample size of individuals at the Ray site (n=15) compared to the Gibson site (n=10).

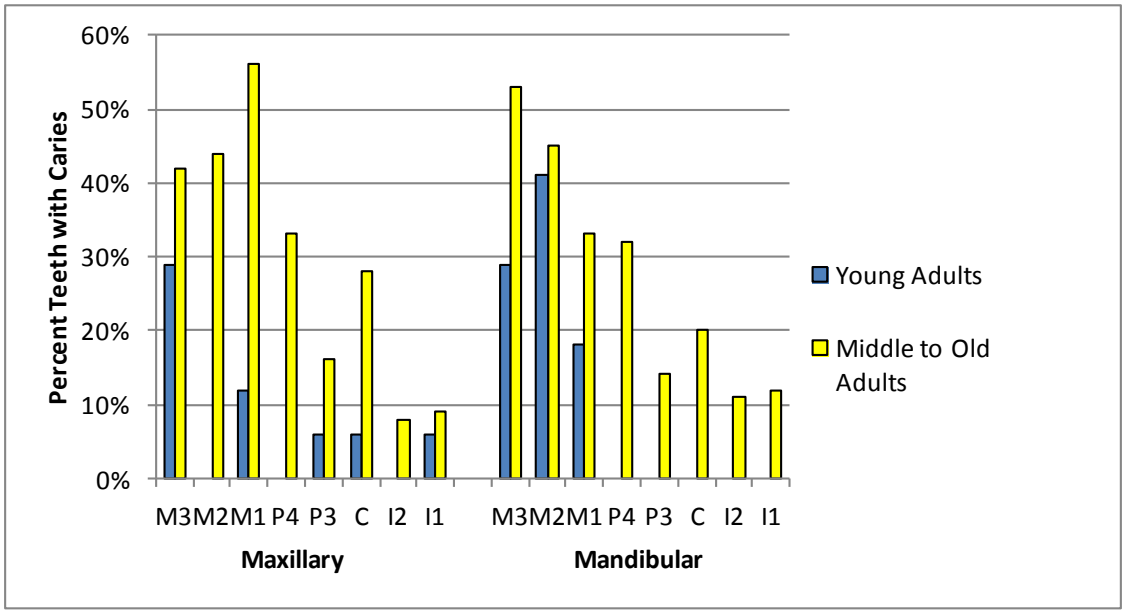

Figure 12. Percent of Caries by Tooth Type between Young Adults and Middle to Old Adults.

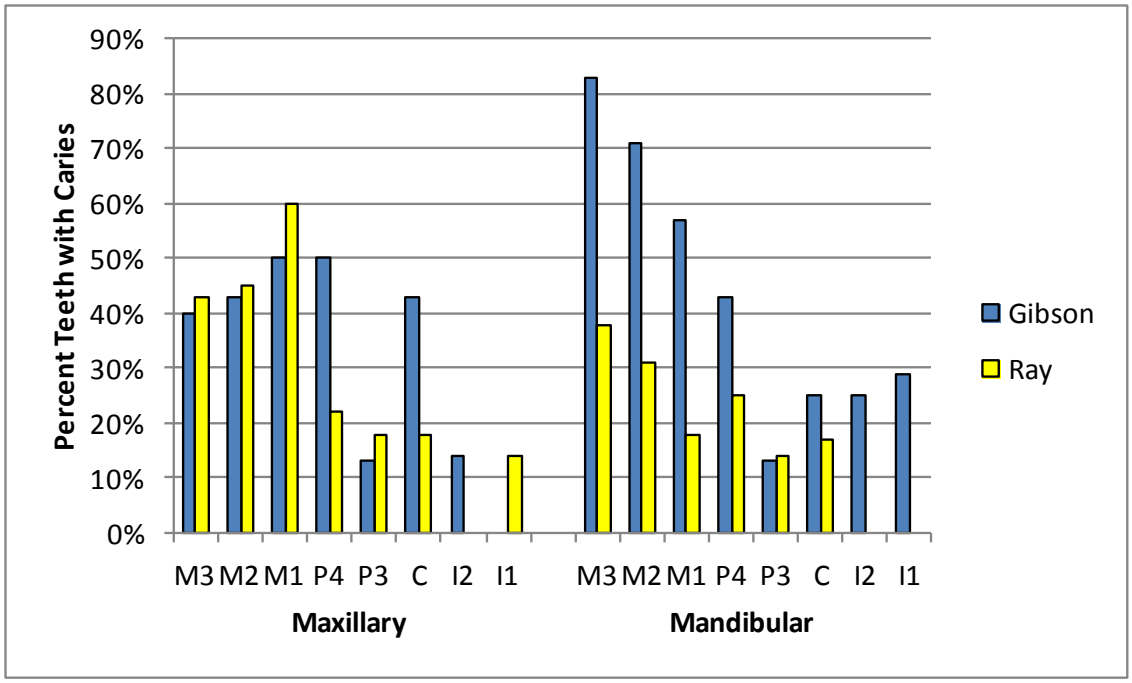

Figure 13. Percent of Caries by Tooth Type of Middle to Old Adults between the Gibson Site and the Ray Site.

When looking at abscess rates in this sample, the Ray site averaged about 3.2 abscesses per individual, with 76 abscesses present, while the Gibson site averaged about 1.75 abscesses per individual, with 42 present. A statistically significant difference ($p<0.05$) was found for abscesses per individual between the young adults (n=19) and middle-to-old adults (n=24). This pattern correlates with the caries rate found between young and middle to old adults. Most of the abscesses observed were found in middle to old adults, as seen in Figure 14, with two individuals having 13 abscesses each. There was no difference in abscess rates when compared by the sex of the individual.

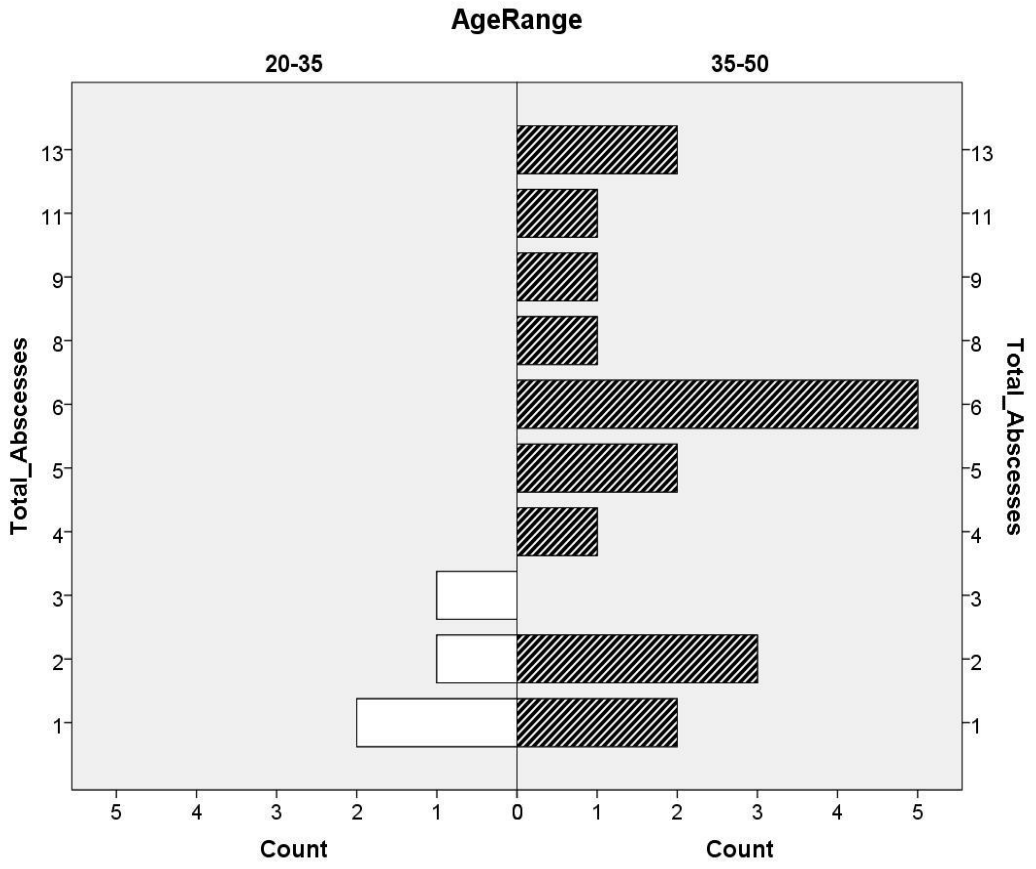

Figure 14. Histogram of the Number of Individuals with Abscesses, Divided by Age Categories.

The occlusal wear on the teeth, primarily in middle to old adults, was extreme where the enamel is completely gone and teeth were difficult to identify. This kind of wear can be explained by the method of food preparation utilized by the people. Most of the implements used for any type of processing would have been made out of stone (Schmidt 2001). Little flakes of stone from crushing, cutting, and peeling the food would have ended up in the food that was consumed causing the grit to wear away on the enamel of the teeth. Attrition scores were average per tooth type where the teeth were present. When comparing the sites, in all tooth types, the Ray site, seen in blue, exhibited higher attrition levels than those at the Gibson site, seen in red (Figures 15 and 16).

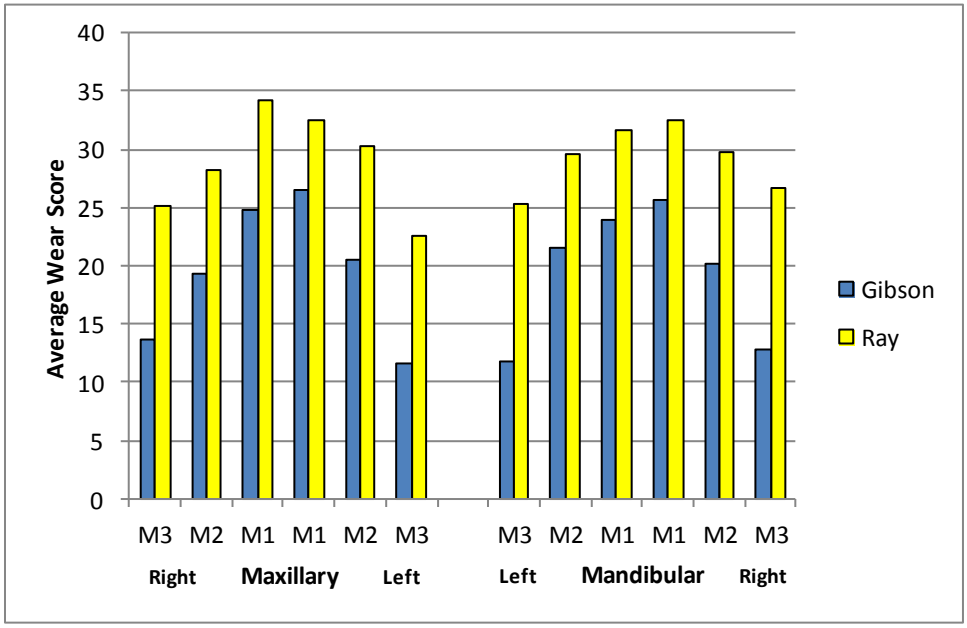

Figure 15. Average Attrition Scores of Molars Between the Gibson and Ray Sites.

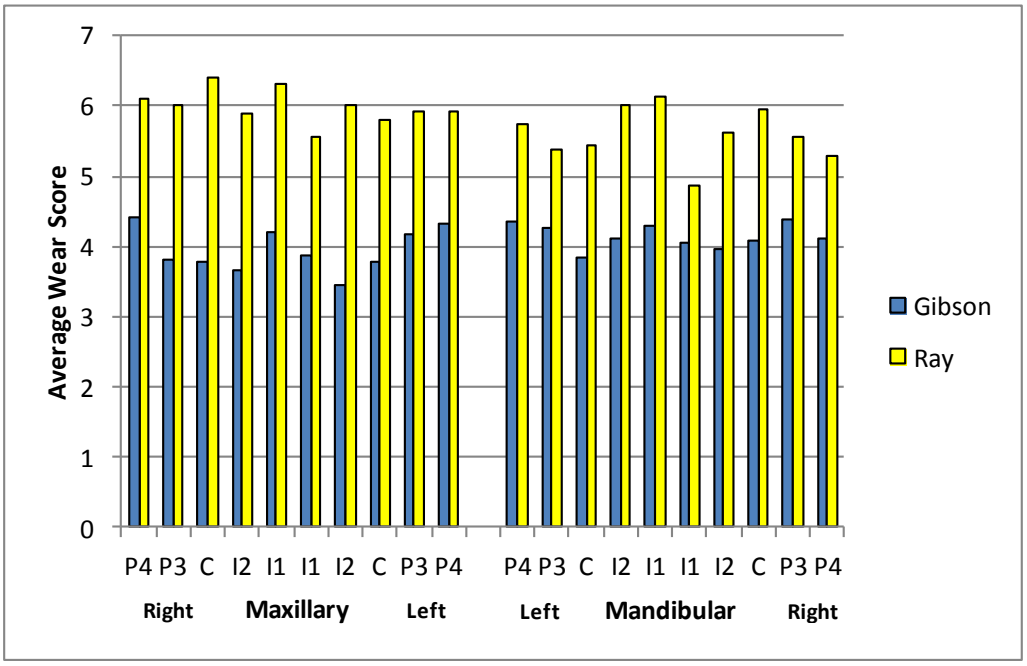

Figure 16. Average Attrition Scores of Non-molars Between the Gibson and Ray Sites.

When attrition rates were compared between the males and females at the Gibson site and as well as at the Ray site, no major noticeable difference was seen. At the Gibson Site, the non-molar teeth in the mandible tended to have more wear in females than in males. Comparing Gibson and Ray females to each other showed much greater attrition at the Ray site than at the Gibson site. The same pattern can be seen with a comparison of males.

Attrition scores compared across the two age categories showed significant differences, since as an individual ages, their teeth will procure more wear. When comparing the respective age categories by site, no difference is seen among the molars of the middle to old adults while several non-molar teeth such as maxillary premolars and canines, exhibit more wear from the Ray site than the Gibson site. Across most tooth types, young adults at the Ray site appear to have more occlusal wear than their counterparts at the Gibson site.

Enamel hypoplasias were present on the teeth of eleven individuals. Of these eleven, eight individuals were estimated to be young adults while the other three were estimated to be middle-to-old adults. Some of the individuals that were estimated to be middle-to-old adults had teeth with most, if not all of the enamel worn away. This would cause any hypoplasias present to be obliterated from the teeth. The enamel hypoplasias were observed macroscopically, which could mean more lines were present on the teeth but could not be observed without a microscope. Of the enamel hypoplasias observed, most teeth just had one distinctive horizontal line present. Interestingly, when two lines were present they were only found on canines. Due to time constraints on data collection, measurements of the enamel hypoplasias were only completed on six individuals. The enamel hypoplasias present in these individuals were recorded by measuring the distance between the linear enamel hypoplasias and the cemento-enamel junction in millimeters using a digital caliper. These heights were placed in a linear

regression equation specific to the tooth type and an approximate age of occurrence is calculated (Goodman and Rose 1990). The exact ages, an age range, and measurements can be seen on Table 4. Age ranges are usually split into half-year increments, as seen in Goodman and Rose (1990). The age range when the enamel hypoplasias probably formed in these six individuals is 2.5–5.5 years of age. Since only hypoplasias from six individuals were measured, little can be extrapolated from the ages at which these disruptions occur, although according to regression equation, most of the enamel hypoplasias formed from 3–4.5 years of age, around the time of weaning.

Table 4. Estimated Age of Enamel Hypoplasia Occurrence.

Individual	Tooth	Measurement (mm)	Estimated Age (years)	Age Range (years)
Gibson 2-3	Lower Canine	2.84	4.8	4.50-4.99
Gibson 2-49	Upper 3rd Pre-	4.29	3.9	3.50-3.99
	Lower 3rd Pre-	4.40	3.1	3.00-3.49
	Lower 3rd Pre-	4.46	3.2	3.00-3.49
	Upper Canine	3.81	3.6	3.50-3.99
	Upper Canine	3.93	3.5	3.50-3.99
	Upper Canine	2.64	4.4	4.00-4.49
	Lower Canine	3.80	3.8	3.50-3.99
	Lower Canine	1.89	4.9	4.50-4.99
	Upper 2nd	3.68	3.0	3.00-3.49
	Upper 2nd	3.62	3.0	3.00-3.49
	Lower 2nd	3.53	2.5	2.50-2.99
Gibson 5-2	Upper 1st	2.97	3.2	3.00-3.49
	Upper 1st	2.93	3.2	3.00-3.49
Ray 1-52	Upper Canine	2.60	4.4	4.00-4.49
	Lower Canine	3.77	4.3	4.00-4.49
	Lower Canine	2.49	5.0	5.00-5.49
	Lower Canine	3.40	4.5	4.50-4.99
	Lower Canine	2.59	5.0	5.00-5.49
Ray 3-39	Lower Canine	2.76	4.9	4.50-4.99
Ray 5-23	Upper Canine	3.88	3.6	3.50-3.99
	Upper Canine	2.63	4.4	4.00-4.49
	Lower Canine	3.56	4.4	4.00-4.49
	Lower Canine	2.12	5.3	5.00-5.49
	Lower Canine	3.67	4.3	4.00-4.49
	Lower Canine	2.15	5.2	5.00-5.49
	Upper 1st	2.39	3.4	3.00-3.49
	Upper 1st	3.98	2.7	2.50-2.99

DISCUSSION

Although there are other features and attributes that can be looked at with this skeletal population, the main dental pathologies addressed in the results section can provide some important information. Overall, the caries rate appears to fit more into an agricultural economy than a mixed economy group. The average caries rate of a population engaging in a mixed economy is around 5 percent while individuals from an agricultural economy usually have caries rates greater than 10 percent (Mickleburgh 2007). The Gibson and Ray sites had caries rates of 15.1% and 16.7% respectively. Though the Middle Woodland cultures of the lower Illinois Valley are usually considered to have had a mixed subsistence pattern, the higher levels of carbohydrates in their diet from oily seeds and starchy grains could have increased their caries rate to that of an agricultural-based population.

Since caries are an age progressive disease, it would only make sense that there would be more carious lesions found in middle to old adults than in young adults. Since there is little to no difference between the sexes, both inter- and intra-site, in caries rates, this might suggest that there was similar access to foods. As previously stated, world-wide there is a general trend that women have higher caries rates then men do (Cassidy 1972; Lukacs and Largaespada 2006). This could be further analyzed if isotopic samples were taken from a sample of male and female teeth to see what types of foods they were consuming. Given that both caries and abscesses often occur together, the higher caries rates in middle to old adults could correlate to the higher abscess rates.

A possible explanation for the larger amount of abscesses at the Ray site could be due to the age distribution. In the entire burial population of the Ray site, there are very few 20–30 year olds and a higher proportion of older individuals (Flotow 2006: 58-63). As an individual ages,

there is a greater likelihood that bacteria will infect the root of the tooth and form an abscess, specifically through the opening of the pulp cavity (Hillson 1996). The exposure of the pulp cavity can occur faster when the occlusal surface is worn away at an earlier age. Since the Ray site exhibited higher attrition rates overall than the individuals at the Gibson site, this could also be a factor in the higher abscess rates at the Ray site. Overall, the attrition rate at both sites was severe, with many older individuals having little to no enamel left on their teeth. This type of attrition was most likely caused by food preparation techniques utilized by the Middle Woodland people as well as the abrasiveness of the foodstuff itself. However, the higher attrition rates at the Ray site are difficult to explain: they may have been processing their foods in a different way than the individuals buried at the Gibson site. Another explanation could be the individuals at the Ray site were eating a diet with courser foods that would increase attrition rates but would have little effect on the caries rate.

Since enamel hypoplasias were present in multiple individuals at both sites, these individuals could have undergone metabolic stressors, such as nutritional deficiencies, while they were a child or some type of physical trauma could have occurred. Another type of metabolic stress that could have caused the occurrence of enamel hypoplasias is the weaning process. Buikstra et al. (1986), discusses how increasing proportions of carbohydrates in diets led to increasing fertility from the Middle Woodland to the Mississippian period. Also mentioned is that food preparation techniques as well as certain crops are contributing to an earlier weaning time, since softer foods can be eaten by young children (Buikstra et al. 1986). This early weaning and putting the child on a more carbohydrate-rich diet earlier in life could be playing a role in the occurrence of enamel hypoplasias. This linear regression model relies on the assumption that teeth grow at a constant velocity in all humans (Goodman and Rose 1990;

Ritzman et al. 2008). Ritzman et al. (2008) compared the linear regression method of aging enamel hypoplasia formation against a method that utilizes a comparative sample that incorporates recent knowledge about dental histology, specifically cusp formation (Ritzman et al. 2008).

Overall, the dental health of the individuals at these two sites had a greater likelihood of deteriorating as the individuals aged. Since there is a similar caries rates found between the two sites, it can be suggested that their diet was of a similar nature with regard to the consumption of carbohydrates. As individuals aged, the occlusal wear became increasing severe to the point that little enamel was left. The presence of enamel hypoplasias suggest some type of stressor, whether it is physical or metabolic. This analysis provides insight into the dental health of the Middle Woodland people during the transition from hunting-and-gathering to horticulture in the lower Illinois Valley and a baseline that can be utilized by other researchers for comparison to later maize agriculturalists in the region.

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