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Sex and the agricultural transition: Dental health among early agricultural females

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SEX AND THE AGRICULTURAL TRANSITION: DENTAL HEALTH AMONG EARLY AGRICULTURAL FEMALES

by

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ABSTRACT

Sex and the Agricultural Transition: Dental Health among Early Agricultural Females

by

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This project analyzed dentition from a sample (*n*=142) of Early Agricultural period skeletons (B.C. 1600-200 A.D.) from the site of La Playa (SON F:10:3), Sonora, México. Data was collected on pathology rates for dental caries and antemortem tooth loss (AMTL) to test the hypothesis that hormone-fluctuations associated with pregnancy increase dental pathology in females. Males and females were not found to have significant differences in caries rates. However, statistically significant differences in AMTL were found with females exhibiting more tooth loss than males (*p*=.022). When compared across age categories, reproductive-age females had substantial increases in AMTL compared to age-matched males.

This pattern suggests that differences in dental health may be sex-based. With decreased birth-spacing associated with sedentism and agriculture, female oral health suffers. Findings from this study, with research from clinical studies on dental health and pregnancy, provide insight into the history of sex-differences in oral pathology and women's health.

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CHAPTER ONE

INTRODUCTION AND LITERATURE REVIEW

Introduction

This study considers biological and cultural factors that affect dental health, with a focus on early agriculturalists from northwest México at the site of La Playa (SON F:10:3). Analysis of sex-variation in dental pathology rates is used to explore the impact that the transition to agriculture had in the lives of women. Two main areas of inquiry are used to examine the dental health of early agriculturalists. These include (1) subsistence behaviors that may have specifically affected women, and (2) clinical research into the effects of pregnancy on dental health.

The population expansion that occurred during the Neolithic demographic transition has been considered the consequence of agricultural community living (Bandy 2005; Boquet-Appel & Naji 2006). Research suggests that the foraging-farming transition and sedentarization of society resulted in higher fertility rates as birth intervals decreased (Armelagos et al. 1991; Boquet-Appel & Naji 2006). Bridges (1989) maintains that the consequences associated with pregnancy, parturition and lactation place specific demands on the health of women. These additional stresses should be considered when assessing the health of women and in looking for patterns within populations (Martin 1994, 1998; Peterson 1994). Martin (2000) investigated maternal morbidity among Ancestral Puebloans in the precontact Southwest and argues that the physiological stress of childbearing was likely as devastating for women in the past as it is for marginalized women today. Martin (2000:281) states, "To view pregnancy and lactation as natural functions to which women are well adapted is misleading. Multiple pregnancies . . . and inadequate nutrition can place even healthy women at risk." With agricultural intensification, women experienced the combined pressure of greater workload as well as increased reproductivity (Bridges 1989; Martin 2000; Peterson 1994).

The American Academy of Periodontology (AAP 2006) states that women are at increased risk for dental health problems over age-matched males due to hormonal changes that occur throughout their lifetime. Recent clinical research suggests that, although the underlying processes are not fully understood, pregnancy-related changes to the oral environment affect dental health in ways that are usually temporary, but may become permanent (Laine 2002). For example, researchers have identified changing hormonal components in the saliva of pregnant women and the presence of irritants that contribute to an inflammatory response of the gum tissues, known as *pregnancy gingivitis* (Burakoff 2006; Laine 2002). Research has established that without proper care, oral conditions can decline, leading to lifelong health problems specific to females (AAP 2006; Lieff et al. 2004).

The transition to agriculture has been well studied for a number of regions of the world, but the effects on maternal health have been largely overlooked in this literature (Steckel et al. 2001; Cohen & Armelagos 1984). Steckel and colleagues (2001) suggest research into long-term health trends and quality of life issues that affect women, but comprehensive data sets have yet to be collected. This thesis synthesizes research from varied disciplines (archaeological, biological anthropology, medical, dental and public health) to assess the dental health of women in the past and to examine long-term developmental trends in the lives of women.

Previous studies are organized in three sections: (1) research on early agricultural populations, (2) fertility changes related to subsistence behaviors and (3) clinical dental research of pregnancy-related hormonal effects on oral health. The hypotheses proposed by this study examine the following research questions:

1. Is there evidence that pregnancy-related factors contributed to the pattern of greater dental pathologies among early agricultural females?
2. Is there a correlation between the population growth of early agricultural communities and the rates of dental caries exhibited by the female segment of these populations?
3. In a population where caries rates are higher for men, do women exhibit greater antemortem tooth loss (AMTL), a portion of which may have resulted from advanced carious decay?

Thesis Design

This study examines the complex interaction between human biology and culture, focusing on the role of reproduction in the health and lives of women. Biological and gender-based health differences, particularly with respect to morbidity and mortality, are important to study because they reveal ways in which inequality and access to resources play out. This study provides in-depth execution and discussion in fulfillment of the research questions summarized above. Data on caries and AMTL frequency from a sample of early agricultural women and men were analyzed for statistically significant differences.

Chapter one reviews literature from studies of early agricultural populations. The discussion includes anthropological research related to agricultural subsistence and fertility rates. The implications of socioeconomic factors are investigated. Clinical dental research of pregnancy and its effects on maternal health is reviewed. The chapter presents a flow chart of biological and cultural variables associated with the subsistence transition to agriculture, as hypothesized by this study (Figure 1.3).

Chapter two provides discussion of the La Playa skeletal collection used to generate the study sample (n=142). La Playa site description and chronology is reviewed. The chapter presents research of the Early Agricultural period in the Sonoran Desert and reviews previous studies conducted at La Playa. Chapter two provides a thorough explanation of methodology and data collection for the study.

Chapter three explains sample data distribution by sex and age categories. The chapter presents frequency rates and describes the statistical analyses that were used. Results from analyses of dental pathologies by sex, across age categories, caries location, and pathology occurrence in association with grave goods are presented. The correction formulas used to adjust caries rates for antemortem tooth loss are explained and results presented. Statistically significant findings are summarized at the end of the chapter.

Chapter four discusses the significance of results in relation to the research goals and implications of findings are presented. The study is evaluated for local significance and placed in broader regional context. Study limitations and recommendations for further research are offered.

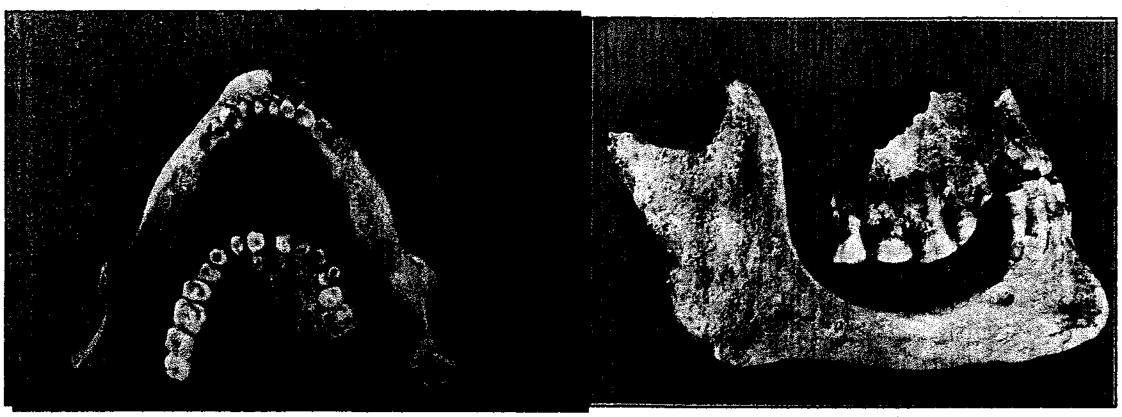
Literature Review

Early Agriculturalists

Steckel and colleagues (2001, 2002) note the importance of investigating the health impacts of the foraging-to-farming transition, as it represents one of the most profound changes in human behavior during the last 10,000 years. The effects of subsistence changes to human health have been well documented from skeletal and dental remains (Cohen & Armelagos 1984; Larsen 2000). Archaeological research of early farming populations has shown that, in general, the shift to agriculture brought negative consequences to human health (Cohen & Armelagos 1984; Larsen 1981, 1995; Steckel et al. 2001, 2002). Early agriculturalists exhibit greater rates of dental decay, malocclusion, and problems associated with nutrition during amelogenesis (e.g., enamel hypoplasia) when compared with hunting and gathering societies (Bridges 1989; Larsen 1995; Turner 1979). Many early agriculturalists focused on single staple crops, and this reduction in dietary breadth brought nutritional inadequacies that resulted in a decrease in bone robusticity and stature (Nelson et al. 1994). Sedentism associated with agriculture led to population aggregation and poor sanitary conditions, promoting the spread of disease (Goodman et al. 1984; Larson 1997, 2000; Martin 1994).

The marked increase in the frequency of dental caries among agriculturalists has been associated with the consumption of softer, processed carbohydrates (Hillson 1979, 1996; Larsen 1987, 1995). Processed carbohydrates allow food to stick to grooves and fissures on tooth surfaces. In addition, Hillson (1996) explains that these softer foods result in less occlusal wear, which allows plaque accumulation with an increase in bacterial colonization that leads to cariogenesis. The development of dental caries is a pathological process involving the destruction of dental hard tissues (i.e., enamel, dentin and cementum) as acid produced by bacterial fermentation causes surface demineralization, eventually forming a cavity as seen in Figure 1.1 (Hillson 1996; Larsen 1995).

Another indicator used to assess dental health in archaeological populations is antemortem tooth loss (AMTL) pictured in Figure 1.2. Hillson (1996) describes AMTL as the result of oral disease and decay that weakens the alveolar bone supporting the dentition. As the gingivae recede and bone resorbs, teeth loosen and are exfoliated. According to Larsen (1995), there is a pattern of increased AMTL that corresponds with the escalating caries rates recorded for agricultural populations.



Figures 1.1 and 1.2: Dental caries and AMTL with alveolar resorption (Finks & Merbs 1991).

The main difficulty in using data to build inferences about the etiology of AMTL is in the absence of the teeth for observation. Hillson (2001) argues that in order to gain perspective on caries in both extant and past populations, understanding the pattern of AMTL is crucial. Another problem with assessing AMTL in archaeological collections is in the variable preservation of dentition from population to population (Hillson 2001). Researchers agree that AMTL indicates a certain level of dental stress and that there is a need for adjusting caries rates for teeth lost during life, although there is no agreement as yet on the method (Brothwell 1961; Duyar & Erdal 2003; Hillson 1979; 2001; Lukacs 1992, 1995). To adjust for AMTL, this study employs Lukacs' (1995) dental 'caries correction factor' (see Materials and Methods for discussion).

According to Larsen (1987, 1997), preagricultural males and females exhibit an equal expression of dental caries. However, for agriculturalists in general, the data indicate that the dental health of women was impacted more negatively than men (Bridges 1989; Larsen 1981; 1995, 2000; Lukacs 1996; Steckel et al. 2001, 2002). Although Lukacs (1996) cautions that higher dental pathology rates for females are not universal. Moreover, the variation between agricultural populations indicates the need to consider patterns in regional and local context.

In his research on the Georgia Coast, Larsen (1981) examined skeletal and dental health indicators from hunter-gatherers and agriculturalists to test the hypothesis that general health would be expected to decline with agricultural intensification. Using a robust skeletal sample of 269 foragers and 342 agriculturalists, Larson found that the data fit the predictive model with an increase in caries for the farming population. When divided by sex, the women agriculturalists exhibit a greater percentage of caries than the men. Larsen (1995:204) observes that within populations adopting agriculture, dental health patterns become ". . . especially clear in view of differences between adult females and males".

Larsen (1987) argues that the male-female differences were likely due to a combination of behavioral factors related to agriculture, sexual division of labor, and dietary differences. He discusses the affects of a diet high in corn, which reduces protein intake while increasing carbohydrates, resulting in restrictions on metabolism and body growth. Larsen (1987:378) suggests that sex-variation in pathology rates may have been in part due to increased female sedentism, based on ethnographic accounts that associate females with early horticultural activities while males remain more mobile by hunting. Thus, the interplay of biological and cultural factors associated with agricultural subsistence might have placed women at risk for greater incidence of dental pathologies.

In their analysis of Hohokam inhumation burials recovered from several pre-Classic and Classic period sites in the Phoenix basin, Fink and Merbs (1991) note a strong correlation between agricultural intensification and the degree of dental pathology. As evidence of prehistoric dental health, Finks and Merbs include data on calculus (hardened plaque deposits), caries, the degree of dental wear, and AMTL. They acknowledge that cultural behavior may have contributed to dental wear, especially for women, who might have been working fibrous materials with their teeth. Even with the high degree of dental attrition, the authors note that Hohokam women exhibited more dental pathologies than Hohokam men. They also suggest that caries and calculus may have contributed to the significant AMTL recorded (Finks & Merbs 1991:303). Although the interpretive model used by the researchers fails to consider sex-specific physiological factors, the Hohokam data provides comparative material with the La Playa sample, as these populations were living in a similar environment and eating a diet high in cariogenic carbohydrates (Watson 2006).

Lukacs (1996) recognized that physiological factors related to reproduction, such as pregnancy, may contribute to sex-based differences in caries rates. His research of prehistoric South Asian populations shows that sample women had a significant increase in caries with agricultural intensification compared to men (Lukacs 1996). Lukacs notes that even today, populations often have sex-differences in caries rates, with females frequently higher than males (Lukacs 1996).

Walker and Hewlett (1990) present arguments against an association between pregnancy-related changes and dental caries. The discussion, however, was based on clinical dental research dating to the middle and early 20th century (summarized in Walker & Hewlett 1990:395). New evidence began to emerge in the 1990s that indicates a significant role for sex-specific factors in women's oral health. Lukacs and Largaespada (2006) refer to this literature in their research of sex-variation in caries rates among the Guanches of the Canary Islands. The authors argue that the higher caries rates found for the women are associated with the increased presence of circulating hormones in the saliva of pregnant women, providing an environment favorable to cariogenesis.

Conclusions regarding the cause of male-female differences in caries rates have been confounded by interpopulation variation. For example, Walker and Hewlett (1990) refer to the West African Bantu, where males were found to have higher caries occurrence, although not significant, than females. However, their AMTL data show that the females had a higher percentage of tooth loss compared to males (1990:389). McClelland (2005) argues that studies such as this highlight the need for population-specific analysis.

According to Larsen (1995), variation between populations is often explained by regional variation, where dietary shifts associated with agriculture and the accompanying biological changes were shaped by local conditions. For example, where agriculture was adopted slowly, as with many Native Americans groups who were casual horticulturalists for centuries, populations retained a broad traditional diet, so changes were not as marked (Kirchoff 1954). Given the importance of population variation, this study examines La Playa data in regional and local context.

The anthropological literature on sex-differences in caries occurrence has traditionally focused on cultural aspects. Lukacs and Largaespada (2006) examine biological factors as contributors that affect the oral environment of women. This thesis interprets biological and cultural interaction during the foraging-to-farming transition, considering dietary, behavioral and biological adaptations that impacted populations and the sub-groups that comprise them. The growth in agricultural populations and sex-specific factors that affect women are central to the hypotheses proposed by this study.

It is important to note that women were not passive "victims" in the decision to adopt agriculture, but active agents in the process (Bar-Yosef & Meadow 1995; Cowan & Watson 1992; Murdock & Provost 1973; Roth 2006). Ethnographic accounts of foragers demonstrate that women were associated with gathering, processing and storing plant foods (Roth 2006). This social pattern meant that women's input was vital when incorporating cultigens into a hunting-gathering economy. Bar-Yosef and Meadow (1995) suggest that women were likely the first to intentionally cultivate plants. Roth (2006:523) argues that "it logically follows that women made the decision to incorporate cultivated maize into their repertoire of plant resources." She suggests that the successful adoption of agriculture was due to the efforts of women who initiated the process.

Farming, Females and Fertility

Even though the health consequences of the adoption of agriculture meant an increase in morbidity and mortality for the most vulnerable (e.g., infants, children, elders and the infirmed), the archaeological record evidences growth of agricultural populations (e.g., larger sites, middens and more structures). Armelagos and colleagues (1991) explain that birth intervals reduced concomitant with sedentism. Eric Roth (1985) has suggested that a causal relationship exists between sedentism and fertility, while Handwerker (1985) argues that it is not sedentism per se, but changes to diet and workload that are implicated in higher fertility rates.

Larson (1995) notes that one of the significant changes associated with the Holocene has been an increase in populations, particularly in regions where agriculture was adopted. Fertility is affected by the interaction of many things, which vary by group as well as by individual. This variability makes it untenable to apply a universal model to explain fertility rates, but the literature does suggest a connection between an increasingly sedentary lifestyle, greater carbohydrate consumption, and higher fertility rates.

According to Schultz and Lavenda (2004), the spacing between childbirth in foraging societies serves to maintain a long-term energy balance in women during reproductive years. Researchers also recognize varying effects on fertility based on different types of activity. For example, high levels of endurance exercise affect the endocrine system and alter hormone levels. These effects are seen with female athletes, such as long distance runners, who begin menstruation at a delayed age and may experience amenorrhea (Schultz & Lavenda 2004).

In a cross-cultural analysis of subsistence mode and fertility rates by Sellen and Mace (1997), the authors found an increase in fecundity associated with greater dependence on agricultural foods. The researchers suggest three mechanisms may be involved: increased food supply to reproductive-age women, reduction in workload, and more readily available weanling foods (Sellen & Mace 1997). Although their results were inconclusive, the discussion is pertinent to this study as it focuses on the interplay between cultural behavior and physiological effects.

Changes in breastfeeding in conjunction with mobility patterns also influence fertility (Pennington 1992; Schultz & Lavenda 2004; Sellen & Mace 1997). Lactation is known to suppress ovulation and, in mobile foraging societies, women breastfeed for lengthy intervals, often feeding on demand for several years (Pennington 1992). In addition, many foraging populations consume a diet high in protein that results in reduced fat levels and decreased fecundity (Schultz & Lavenda 2004). Schultz and Lavenda argue that when the dietary ratio of proteins to carbohydrates is altered, women can experience increased fat stores and a rise in fertility.

Eshed and colleagues (2004) cite ethnographic studies of foraging populations that exhibit a decline in fertility rates from increased mobility or seasonal weight fluctuations, which can reduce fertility even with adequate nutrition. This results in the greater birth intervals traditionally seen among hunting and gathering societies. Hausman and Wilmsen (1984) argue that when !Kung San are more sedentary, they gain weight and experience less seasonal fluctuation with a reduction in birth intervals.

In the Levant, Eshed and colleagues (2004) found that the Neolithic brought an earlier onset of menarche with an increased number of births. The authors discuss the implications of these factors for Neolithic women in comparison with Early Natufian women (Eshed et al. 2004). They found a higher mean age at death for Natufian females compared to males, with a reversal occurring during the Neolithic. Findings show a lower mean age at death for Neolithic women, indicating that preagricultural Natufian women were living longer. The researchers suggest the lower age at death of agricultural women was due to more frequent childbirth and associated risks.

Research on the transition from foraging to farming indicates multifactorial effects to female dental health. The following flow chart (Figure 1.3) illustrates the interaction between biological and cultural factors, as postulated by this study.

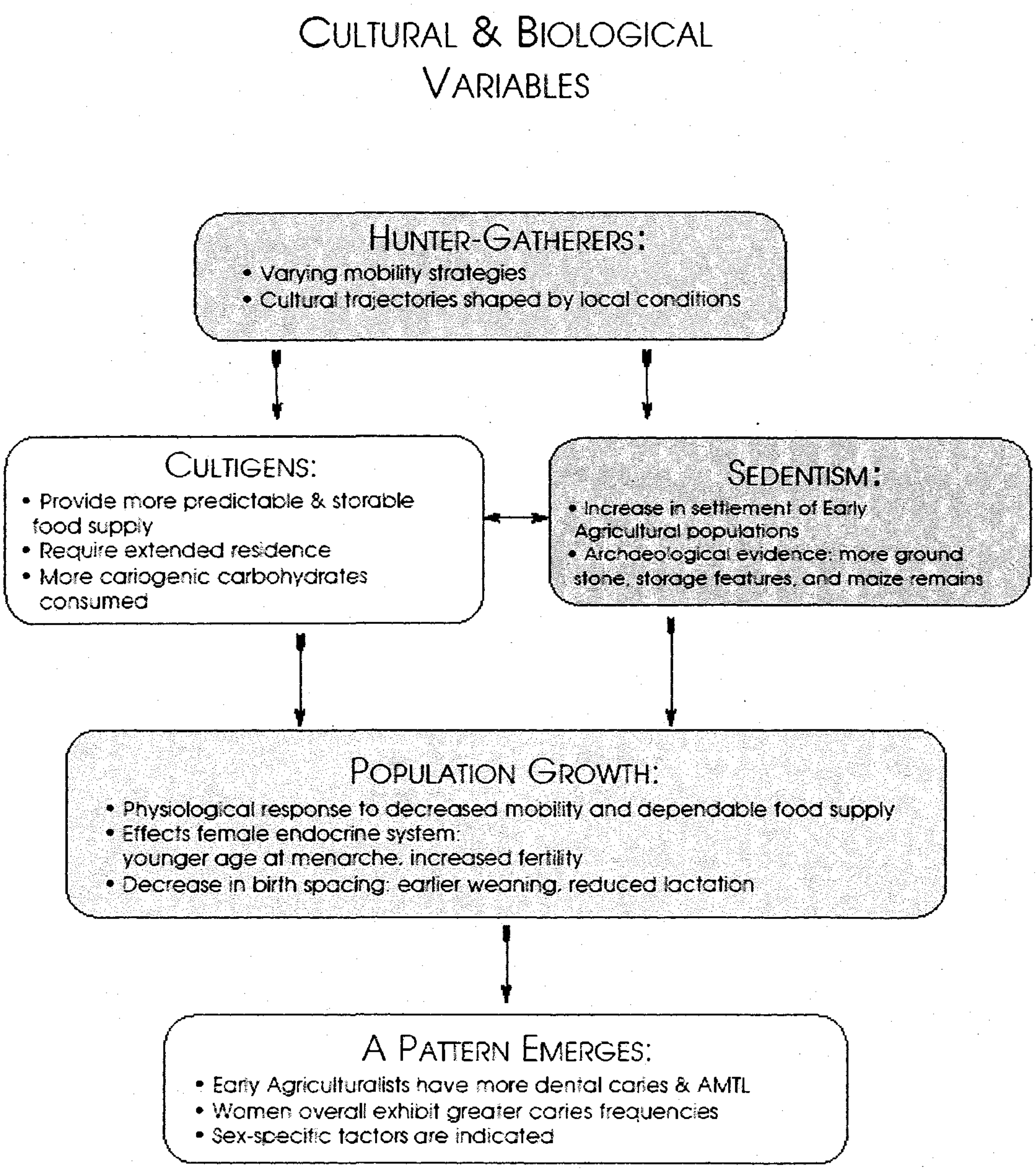


Figure 1.3. The flow chart shows the hypothesized interaction between biological and cultural variables.

Socioeconomic Factors

In intrapopulation comparisons, data on grave goods, and skeletal and dental pathologies, have been used to examine the implications of social status. Powell (1988) argues that lower status may hinder access to more nutritional foods, thus by examining remains, the impact of social inequality on human health can be better understood. Powell (1988) used this method to research status and health among Mississippian agriculturalists at the Moundville site in western Alabama. Moundville (AD 1000-1450), situated along the Black Warrior River, was part of a highly stratified polity with a subsistence based on intensive maize agriculture. Using absence, or presence and type of grave goods, Powell (1988:73) organized a skeletal sample (*n*=564) into elite and sub-elite, dividing groups by sex and age. She analyzed caries and AMTL rates as evidence of differential access.

Ambrose and colleagues (2003) conducted bone analyses from a burial sample (*n*=272) from Mound 72 at Cahokia. As a major urban center in Mississippian culture, Cahokia was heavily inhabited from ca. AD 800 to 1400. The researchers argue that the analysis can be used to examine social status based on burial treatment and prestige grave goods (Ambrose *et al.* 2003). Findings show that individuals buried with prestige goods had better health than individuals with no goods, suggesting that high status individuals had greater access to protein rich resources.

These studies investigate social status in a complex chiefdom, where status is hierarchically organized. Among Late Archaic foragers as at La Playa, social status likely would have been related to individual achievement. However, the evidence for a growing shell industry at La Playa indicates specialization, which could have resulted in differential access to resources. In addition, Walker and Hewlett (1990:396) argue that even in "egalitarian" foraging societies, better access to quality resources for certain individuals result in status-related health differences. They found evidence for differences in social status among Central African foragers (Aka, Mbuti and Efe), comparing the dental health of "leaders" to "non-leaders". The leaders show signs of disease in or are missing a total of 12.5% of their teeth, while non-leaders had three times as many teeth diseased or missing (31.9%) (Walker & Hewlett 1990: 388).

Clinical Dental Research

Clinical research has demonstrated that physiological factors affecting maternal oral conditions can impact the health of women in critical ways (Bobetsis et al. 2006; Boggess & Edelstein 2006; Burakoff 2003; Laine 2002; Lieff et al 2004; Silk et al. 2008). According to the American Academy of Periodontology (AAP 2006), compared to men, women are at an increased risk for oral health problems due to hormonal fluctuations throughout their lifetime. With the onset of menstruation, the increase of circulating hormones can irritate gum tissue. During pregnancy, hormonal and vascular changes are associated with an inflammatory response that impacts oral health (Burakoff 2003). In addition, menopause has been associated with bone loss and current research suggests this extends to alveolar bone loss (Jeffcoat et al. 2000). As a result of these findings, it is understood that without proper oral care, women can experience lifelong dental health problems (AAP 2006). The cycle of dental decline can be further perpetuated by factors such as lack of proper nutrition and tooth loss (Silk et al. 2008).

There is an old saying that may have some basis in truth: "A tooth lost for every child." A condition known as *pregnancy gingivitis* (Figure 1.4), where reddened gum tissues swell and bleed easily, can develop from the physiological and hormonal changes that occur during pregnancy (Lieff et al. 2004). According to Laine (2002), an increased circulation of progesterone begins when the placenta takes over the regulation of hormone production during the second trimester. During this time, the blood ratio of estrogen to progesterone changes from 100:1 to almost 1:1 by pregnancy term (Laine 2002). The circulating progesterone plays a major role in tissue response and the vascular system, maintaining the endometrium (the mucous membrane lining the womb) and preparing mammary glands for lactation. Due to the vascularization of body tissues, gingivae become inflamed. Fluid retention (gingival edema) can also cause loosening or extrication of teeth from their bony socket. Periodontal pockets may form as edema-related gingival smoothing and thickening of the gingival margin occurs (Laine 2002).

Figure 1.4. Maternal gingivitis (AAP 2006).

Laine (2002) explains that healthy gingivae do not differ metabolically (i.e., in chemical composition) between pregnant or non-pregnant states, but the response of the tissue to irritants does change. It is also known that the presence of female hormones in saliva increase during pregnancy. Though pregnancy does not cause gingivitis, the changes to gingival blood vessels contribute (Neville et al. 2008). The vascularized gum tissues are more permeable and sensitive to bacterial substances, making a more favorable environment for gum disease (Laine 2002; Neville et al. 2008; Silk et al. 2008).

In addition, oral flora change as salivary pH is altered (Laine 2002). Healthy salivary pH ranges between 6.5 to 7.5, providing a natural defense against excessive acid in the mouth. When the oral environment is too acidic, tooth surfaces become weakened and bacteria can proliferate. According to Hillson (1996:277), lowered pH alkalinity results in tooth demineralization, establishing an environment favorable to cariogenesis. With the decrease in salivary alkalinity, the ability of saliva to neutralize acids is diminished.

In addition, the reduced calcium and phosphate content in the saliva of pregnant versus non-pregnant women results in increasing salivary levels of *Streptococcus mutans* (Laine 2002). Hillson (1996) explains that *S. mutans* is a highly cariogenic bacteria, that rapidly processes sugars and produces acids. This microbe is infrequent in normal plaque or with a low sugar diet, but as dietary sugars increase, the bacteria have an adaptive advantage. The increased presence of *S. mutans* with changes during pregnancy (e.g., frequent meals) may favor acidogenic activity that decay tooth surfaces (Laine 2002).

No single factor can be isolated in the multicausal etiology of dental caries. However, research has shown that the oral environment alters significantly during pregnancy, with adverse effects to maternal dental health (Laine 2002; Lieff et al. 2004; Neville et al. 2008; Silk et al. 2008). Research findings indicate that the vascularization of gingival tissues, the changes in salivary pH with increased demineralization of tooth surfaces and decreased ability for remineralization, and an increase in the presence of cariogenic bacteria combine to facilitate cariogenesis (Laine 2002).

CHAPTER TWO

MATERIALS AND METHODS

The hypotheses tested in this study postulate a relationship between the adoption of agricultural foods, reduced mobility strategies and changes exhibited in early agricultural women's dental health. Previous investigations demonstrate a pattern of differences between male and female early agriculturalists (Bridges 1989; Larson 1981; Lukacs 2006), as well as a connection between female life-changes and dental health (Bobetsis et al. 2006; Burakoff 2003; Laine 2002). To evaluate the interaction between these biological and cultural factors, the dental health of a burial sample (*n*=142) from La Playa is analyzed in light of anthropological and clinical dental research. Analyses examine if a pattern of statistically significant sex-differences in caries and AMTL rates can be identified for reproductive-age La Playans.

The La Playa burial collection was chosen for this study as a representative sample of Early Agricultural Period populations in the Desert West (Figure 2.1). While many Southwestern osteological collections are limited by time depth and by sample size, the La Playa collection spans the Early Agricultural Period (B.C. 1600-200 A.D.) of the southern Arizona sequence and represents the largest early burial collection in the Desert West (Watson 2005). The ongoing archaeological project at La Playa is designed to excavate eroding burials and is conducted with the cooperation of the México government, using archaeologists, students and volunteers from México and the United

States. The collection has potential for future collaborative research, traversing contemporary international borders.

La Playa Site Description and Chronology

The La Playa site encompasses a 12 square kilometer (km) area approximately 125 km (77 miles) south of the international border and located 43 km (26 miles) west of Santa Ana, Sonora (Figure 2.1) (Carpenter & Villalpando 2002; Johnson 1963). The modern town of Trincheras and the terraced hill site known as *Cerro de Trincheras* are located roughly 11 km (7 miles) south of the site (Johnson 1963).

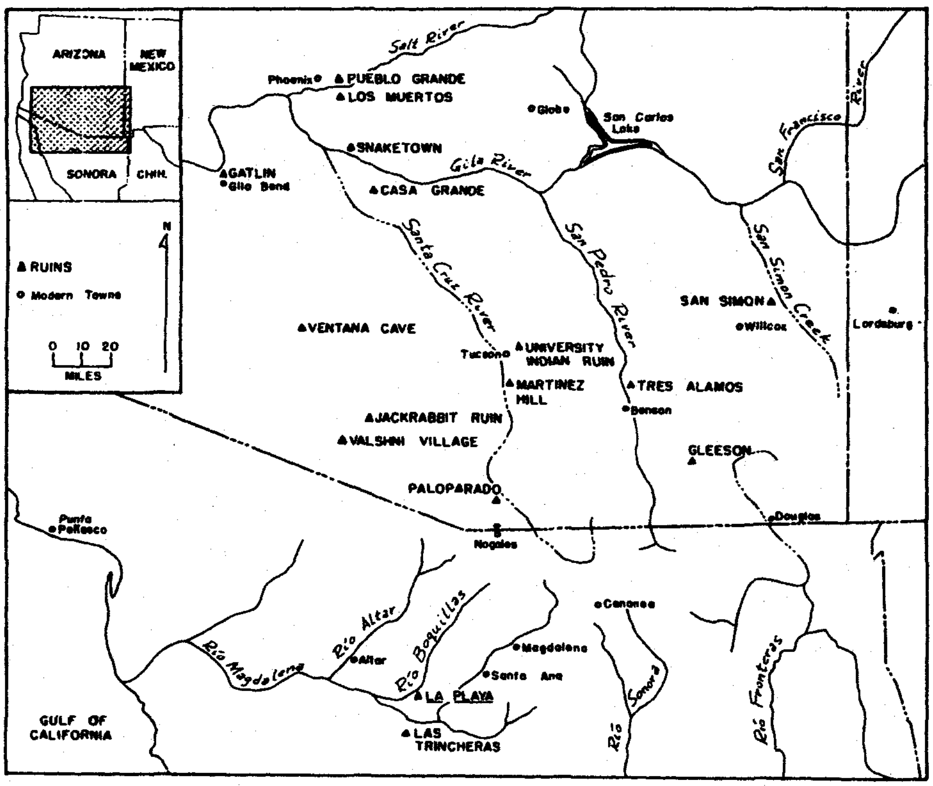


Figure 2.1. Map of southern Arizona and Sonora with archaeological sites (Johnson 1963).

The site is located in an alluvial floodplain at the base of the Cerros Boquillas, which are rugged hills comprised of fluvial deposits of shale, siltstone and quartz (Johnson 1963; McLaurin 2007). The Rio Boquillas, a permanent water source flowing as recently as the 1960s, enters the site in the northeast corner through a gap in the hills (Johnson 1963; Watson 2005). Today the Rio Boquillas is a deeply entrenched arroyo that cuts through the site (Watson 2005).

La Playa has experienced extensive erosion of alluvial sediments due to torrential summer rains, exposing a large quantity and diversity of burials, cultural material, and roasting pits. To date, however, no structures or other features (e.g., storage pits) have been identified, possibly due to poor preservation. Previous investigations found evidence for relatively continuous occupation dating from the end of the Pleistocene (circa 11,000 years ago) (Carpenter & Villalpando 2002). Due to erosional processes acting upon the site, many of the artifacts lack primary context, which has led to problems of interpretation. Most of the recovered cultural material has been associated with the Early Agricultural period and the later Trincheras culture (AD 800-1100) (Carpenter & Villalpando 2002; Watson 2005). All of the recovered burials thus far have provided radiocarbon dates to the Early Agricultural period (for more details, refer to page 28). The condition of skeletal remains varies from small surface scatter of disarticulated bones to well-preserved, intact burials (Watson et al. 2006).

La Playa lies in the Sonoran Desert, with a hot dry climate and annual precipitation that ranges between three to fifteen inches, primarily from summer monsoons (Figure 2.2). The topographical zones of the Sonoran vary from grasslands and desert floodplains to uplands and jagged mountain ranges (see Figures 2.3). Fish and colleagues

(1992) describe the floodplains of the Sonoran as an environment with plentiful plant resources that include a variety of edible cacti (e.g., agave, saguaro) and leguminous trees (e.g., mesquite, palo verde) (Figure 2.4). Local game consists of 130 mammal species, over 500 bird species, roughly 120 reptiles and 30 native fresh-water fish (Dimmitt 2007).

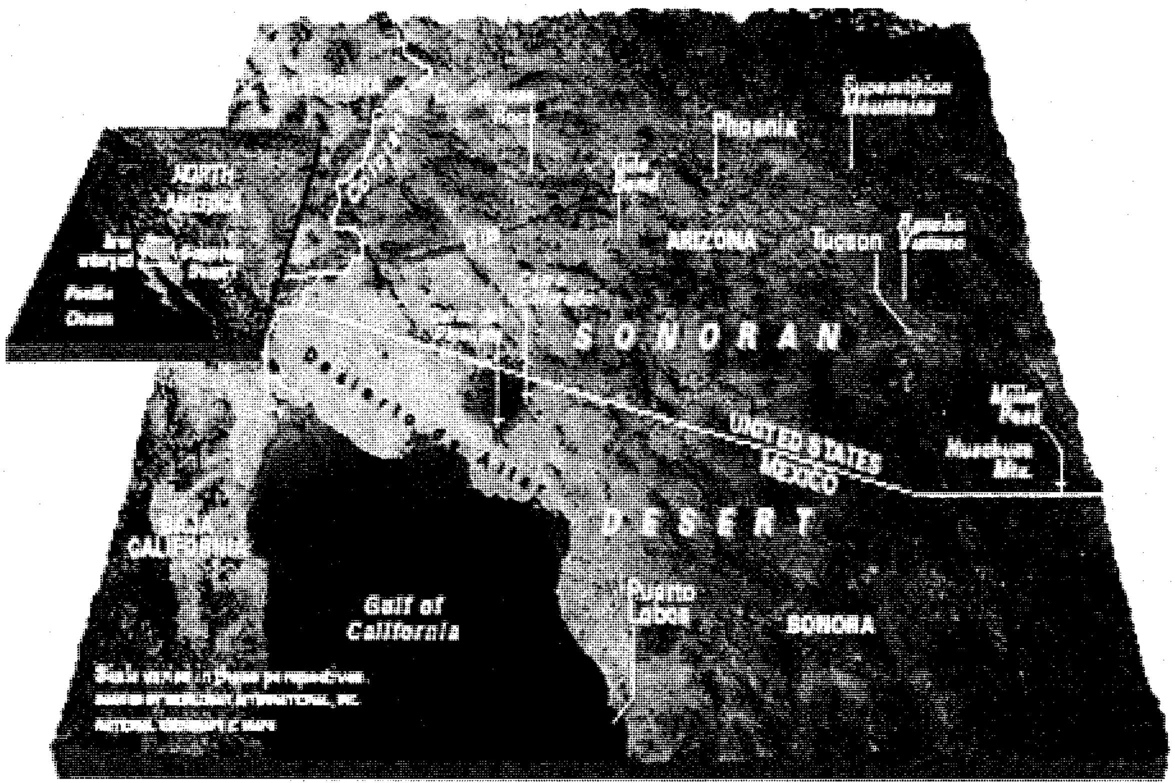


Figure 2.2. Map of the Sonoran Desert (www.NationalGeographic.com).

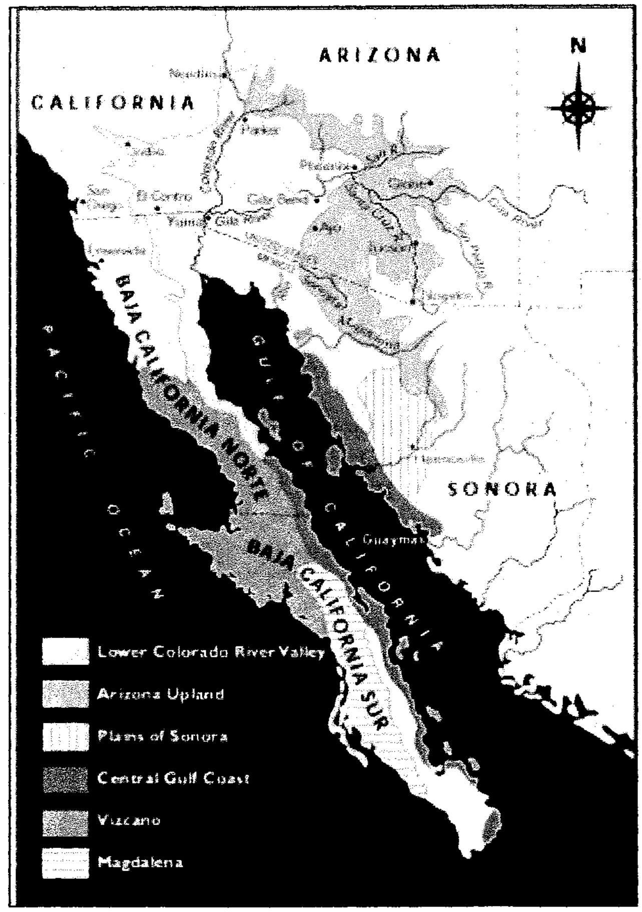


Figure 2.3. Six topographic subdivisions of the Sonoran Desert (Dimmitt 2007).

Topographically, La Playa is part of the Basin-and-Range geologic system. These systems form from the action of the earth's plates pulling apart. Rocks break along faults, rising to mountain ranges while valleys or basins stretch between. This topography influences the climate by blocking moist air masses between the mountains. The ranges trend northwest to southeast, paralleling one another and basins between are covered with sandy sediments that form as rain washes into the valley from the mountain slopes (Dimmett 2007).

Researchers suggest that the low elevation and seasonal flooding of desert basin alluvial fans provided the "biological requisites of corn and farming" (Fish & Fish

1994:86). The diversity of game and plant foods combined with the emerging use of cultigens made La Playa an environment favorable for extended residence (Fish & Fish 1994; Fish et al. 1992; Watson 2005; Wills 1988).

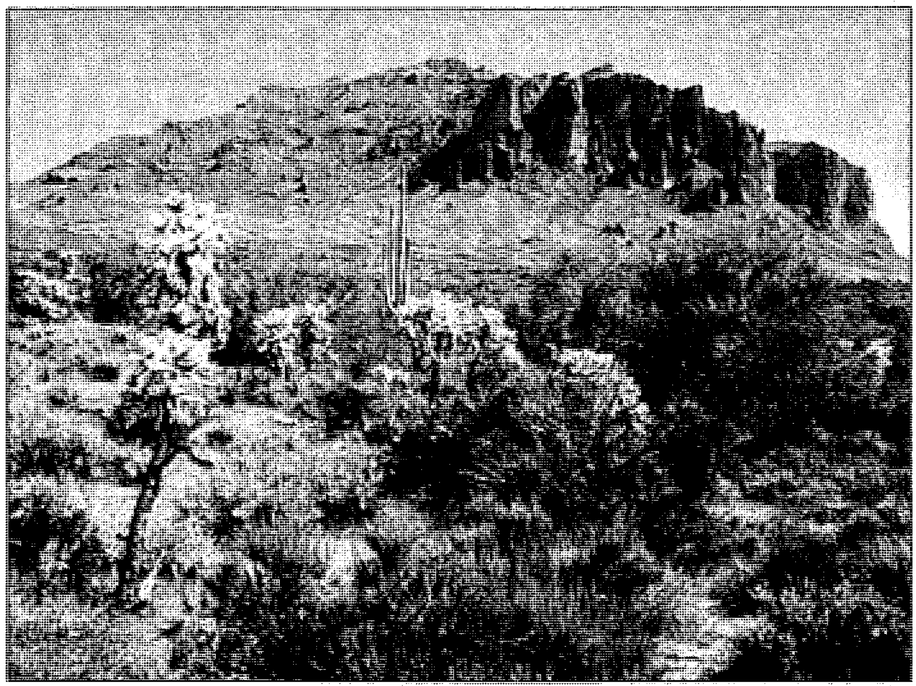


Figure 2.4. Vegetation in the Sonoran Desert (Dimmitt 2007).

Fieldwork at La Playa has yielded a substantial burial sample spanning a temporal range suited for research into the agricultural transition in the Sonoran Desert (Watson 2005). The soil matrix surrounding the burials consists of cultural material and layers of alluvium deposited during the Holocene (Watson 2005). In a geological study, McLaurin (2007) found that floodplain deposits had a minimum thickness of 8 m resulting in homogenous silt that has remained stable since the site was inhabited. The fine, Holocene soil has a high clay content (24.5%) with variable compaction and little discernible stratigraphy (Watson 2005). Remains are exposed as site erosion deflates the matrices that encase remains, effectively exposing burials to further decomposition processes (i.e., from sun, wind, rain, and animals). A thick paleosol made of red, sandy clay can be seen beneath the Holocene soil in the lowest elevations of the floodplain (Watson 2005). No cultural remains have been recovered from this stratum, but the remains of Pleistocene fauna including camel, horse, tortoise and mammoth have been observed.

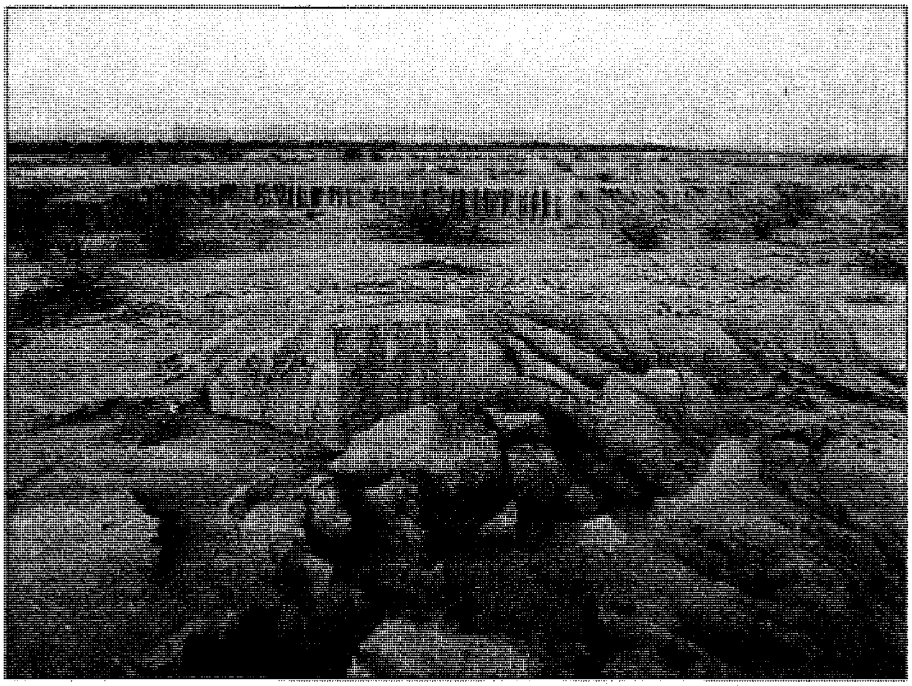


Figure 2.5. Vertical erosion pictured at the *Hornos Alineados* locus of La Playa (photo by David Becker 2007).

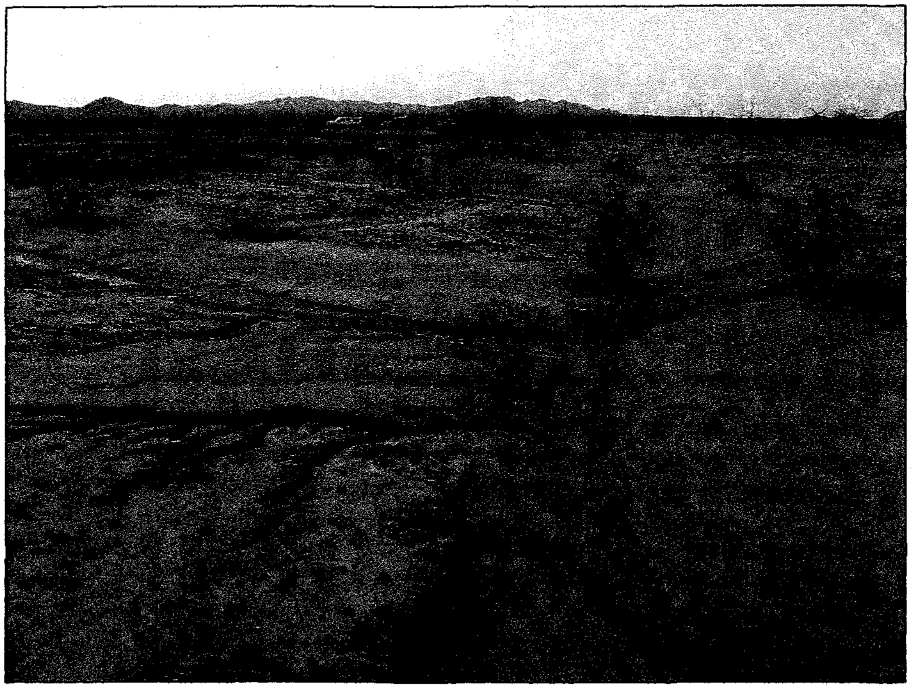


Figure 2.6. Surface erosion at *El Canal* locus of La Playa (photo by David Becker 2007).

To date, 305 burials have been recovered primarily from four site loci that are defined by distinct intra-site topographic zones (Watson 2005). During his research, Watson identified internal drainage patterns particular to each locus. For example, the *Los Monticulos* locus is eroding vertically (Figure 2.5 shows vertical erosion), but *El Canal* is eroding horizontally from sheet wash erosion (Figure 2.6). As a result, burials in *Los Monticulos* were frequently removed from primary context and some had completely eroded away burials, while burials in *El Canal* were only slightly exposed leaving most of the remains in situ (Figures 2.7 and 2.8) (Watson 2005). The *Los Entierros* and *Hornos Alineados* (refer to Figure 2.5) loci are located parallel to one another, with drainages that flow east to west, and both have extensive vertical cut-bank erosion (Watson 2005).

Figure 2.7. Cranium of Burial 437 exposed by sheet wash erosion at *El Canal* (Watson 2005).

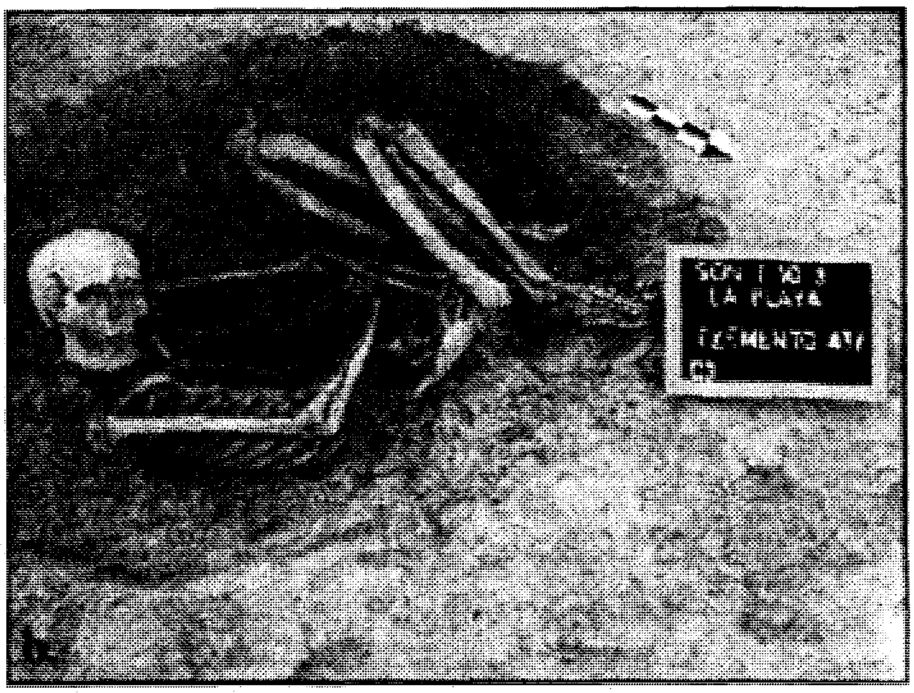


Figure 2.8. Burial 437 after excavation (Watson 2005).

In order to place remains in temporal context, Watson defined differences in depths of erosion at each loci and grouped burials with similar radiocarbon dates and recovery depths (this was possible due to the stability of the Holocene soil horizon). In this manner, he was able to assemble sub-samples for each archaeological phase. This allowed a large portion of burials to be placed in a temporal framework for analysis of dental health at La Playa over time (Watson 2005).

The position of recovered burials have been predominately tightly flexed, but semi-flexed, seated and extended inhumations were recorded also (Figure 2.8 shows semi-flexed position). The collection is evenly divided by sex and is representative of all age groups. In general, the La Playa population exhibits good skeletal and dental health suggesting adequate nutrition and a low incidence of infectious disease (Watson 2005; Watson et al. 2006). Grave goods accompany approximately 23% of the burials, with a variety of offerings such as shell ornaments and ochre treatment at interment (Watson 2005).

Radiocarbon dates from excavated burials provide a range between 3720 ± 320 to 1530 ± 40 BP (3100 B.C.-A.D. 620 cal.) (Watson 2005). It is important to note that recent changes in the traditional understanding of preceramic cultures of the Southwest have led some researchers to reassign the Late Archaic as the Early Agricultural Period (Huckell 1995). Wills (1988) observed that changes in Late Archaic point forms are related to the need for more efficient and extractive weapons, suggesting reduced mobility. Other data (e.g., storage pits, trash middens) also point to increased sedentism. Such changes are seen as evidence that the "conditions which would permit adoption [of cultigens] appear to be in place" by this time period (Wills 1988:89). Thus, the radiocarbon dates provided by the burials span the Early Agricultural period (1600 B.C. to 200 A.D.). At La Playa, this appears to have been a time of increasing local investment, intensified use of cultigens, and population growth as evidenced by the extent of the site and the large number of burials (Watson 2005).

The Early Agricultural Period is divided into two phases, the San Pedro (c. 1600-800 BC) and the Cienega (c. 800 B.C.-A.D. 200). The San Pedro phase is defined from eleven alluvial sites in the San Pedro River Valley (Wills 1988). This phase is characterized by a shift from highly mobile, foraging subsistence to increasing sedentism. Recent research in southern Arizona suggests mobility patterns during the San Pedro phase involved semi-sedentary occupations (Roth 1996; Roth & Wellman 2001), although Huckell (1995) has argued that these groups were fully sedentary agriculturalists.

Although San Pedro sites recorded in upper elevations do not present similar evidence for agriculture (Roth 1996), characteristics identified with lower bajada sites (e.g., La Playa) relate to increased sedentism and the introduction of maize (e.g., structures, large middens, roasting pits, and maize remains) (Huckell 1995; Roth & Wellman 2001; Roth & Freeman 2008). Diagnostic cultural material include side-notched, long-blade projectile points, limited ground stone tool types and shallow earthen depressions (Huckell 1995; Wills 1988). The San Pedro phase at La Playa represents mixed-economy subsistence with the technology in place suitable for agricultural intensification (Watson 2005).

The Cienega phase is characterized by larger settlements, increased populations and greater reliance on domesticated cultigens (e.g., *Zea mays)* (Huckell 1995). Cienega projectile points are large corner-notched triangular points with tapered necks and convex bases (Huckell 1995). This phase is usually defined by domestic features, roasting and storage pits and an increase in ground stone presence and complexity (Diehl 2005; Mabry et al. 1997). At La Playa, the lack of domestic features makes it difficult to document increasing sedentism. However, the Cienega phase at La Playa is associated with evidence of growing local investment, marked by the ubiquitous presence of ground stone and remains from a shell industry dating to this period (Watson 2005).

Previous Investigations at La Playa

Emil Haury (1985) observed that in the search for Southwestern cultural origins (Figure 2.9), "Eyes turned to the south, México, and we began to sense that much of the Southwest's vitality sprang from there…" (1985:389). Regretfully, the international border between the United States and México impacted archaeological regional study for many decades, resulting in a dearth of projects south of the border (McGuire & Villalpando 1998).

While recording sites in Sonora, George Fay (1955:566) recognized the potential of the state as a "contact area" for Southwestern marginal cultures. He suggested investigations in the northwest of México, emphasizing the importance of Sonoran prehistory and the need to incorporate studies into regional understanding (Fay 1955:567). Fay (1955:566) also realized that the border presented "an invisible barrier" to integrating Méxican influence northward. More recently, northwest México has been recognized as a region of cultural influence in the prehistoric Desert West.

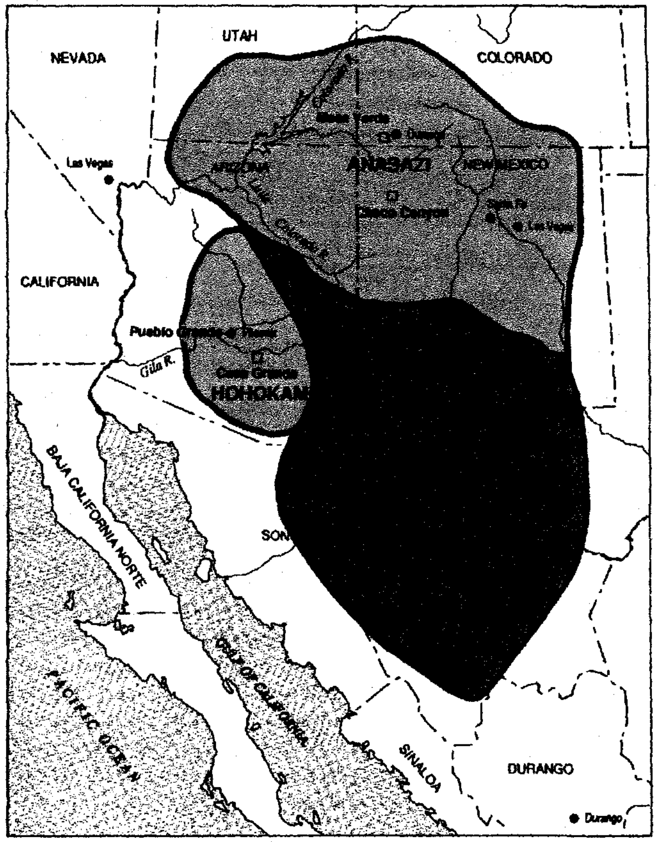


Figure 2.9. Culture areas referred to as Anasazi, Hohokam and Mogollon in the American Desert West (Dimmitt 2007).

Some researchers, such as Wills (1988), suggest that vegetation changes (e.g., an increase in grasses and desert flora) that occurred during a warming, drying trend of the middle-Holocene (known as the Altithermal circa 4500-7000 years ago) would have provided hunting and gathering societies with resources for reduced mobility, particularly along rivers. However, the affects of the Altithermal is debated by many, such as Martin (cited in Roth & Freeman 2008), who argues for a warmer, moister period with increased summer precipitation. Fish and colleagues (1992) suggest that the alluvial soil and riverine setting of sites such as La Playa would have provided environmental conditions that included potable water and abundant staple resource availability.

La Playa was identified as an archaeological site in 1928 by two geographers, Carl Sauer and Donald Brand, as they conducted a survey of northern Sonora (Fay 1955). They described the site as providing evidence for prehistoric occupation of the floodplain. However, Sauer and Brand had focused primarily on the highly visible *Cerro de Trincheras* site adjacent to the modern town of Trincheras (Johnson 1963). In 1936, Woodward suggested that La Playa had been a bracelet manufactory based on the extensive deposit of *Glycymeris* shell detritus on the site surface.

Little further investigation was done at La Playa until 1963, when Alfred Johnson studied the Trincheras occupation (A.D. 800-1100) of the site, identified by Trincheras Purple-on-Brown and Purple-on-Red ceramic types. Johnson's objective was to relate the Trincheras culture with well-known regional archaeological manifestations. He concluded that La Playa may have been "a specialized site" that had provided "seasonally abundant" wild plant foods (1963:184). Johnson (1963:184) identified parallels with the Desert Culture of the Hohokam and thus concurred with Haury's suggestion that the Trincheras culture "be brought into the general Hohokam picture".

Over the past 12 years, La Playa has been excavated as part of *Proyecto La Playa*, a joint venture between *Centro Instituto Nacional de Antropología e Historia* (INAH), Hermosillo, and the *Universidad de las Américas* (UDLA), Puebla (Carpenter & Villalpando 2002). Investigations by Carpenter and Villalpando began in 1995 when INAH, in collaboration with UDLA, financed the project. The project was designed to salvage cultural material and remains from erosional damage. Torrential rains in some areas have washed cultural and skeletal material over the site, leaving a surface similar to desert pavement (Figure 2.10 and 2.11). Historically the site has been used as a cattle ranch and sugar cane was also cultivated there, so that in addition to disintegration from heavy rains, ranch activities brought additional site disturbance (Carpenter & Villalpando 2002).

Carpenter (with *Departamento de Antropología*, UDLA, Puebla) and Villalpando (of Centro INAH Sonora) addressed questions relating to site chronology, subsistence and regional interaction. The researchers identified the oldest occupation as associated with Paleoindians circa 11,000 B.C, found evidence for hunter-gatherer use of the site during the Archaic (7500 to 1500 B.C.), and documented an Early Agricultural preceramic component (c. 1600 B.C. to A.D. 200) (Carpenter & Villalpando 2002). The project has yielded vast assemblages of ceramics, faunal remains, features, ground stone, lithics, macrobotanical remains, shell, and burials (both human and dog) (Figure 2.12 shows a dog burial) (Watson 2005).

Figure 2.10. The site surface covered with cultural material (photo by David Becker 2007).

Figure 2.11. Jim Watson with students pointing to exposed remains on site surface (photo by David Becker 2007).

Figure 2.12. Dog burial excavated at La Playa (Watson 2005).

Ochoa (2005) found that the most frequently represented artifacts (54% of all projectile points) dated to the Early Agricultural Period and were diagnostic of either the San Pedro or Cienega phases (Figures 2.13 and 2.14). Carpenter and Villalpando (2002) recorded ground stone artifacts including cobble manos, slab-and-basin metates, trays, and hammerstones (Figure 2.15). Shell debris and ornaments along with rasps, awls and antler punches indicate local shell jewelry production (Figure 2.16). Forty-two out of forty-nine radiocarbon dates from burials and roasting features date to within the Early Agricultural Period and both phases are equally represented by artifacts, features, and burials (80 burials have been assigned to San Pedro and 83 to Cienega) (Watson 2005). Thus, the archaeological remains recovered to date provide suitable evidence of the Early Agricultural component at La Playa.

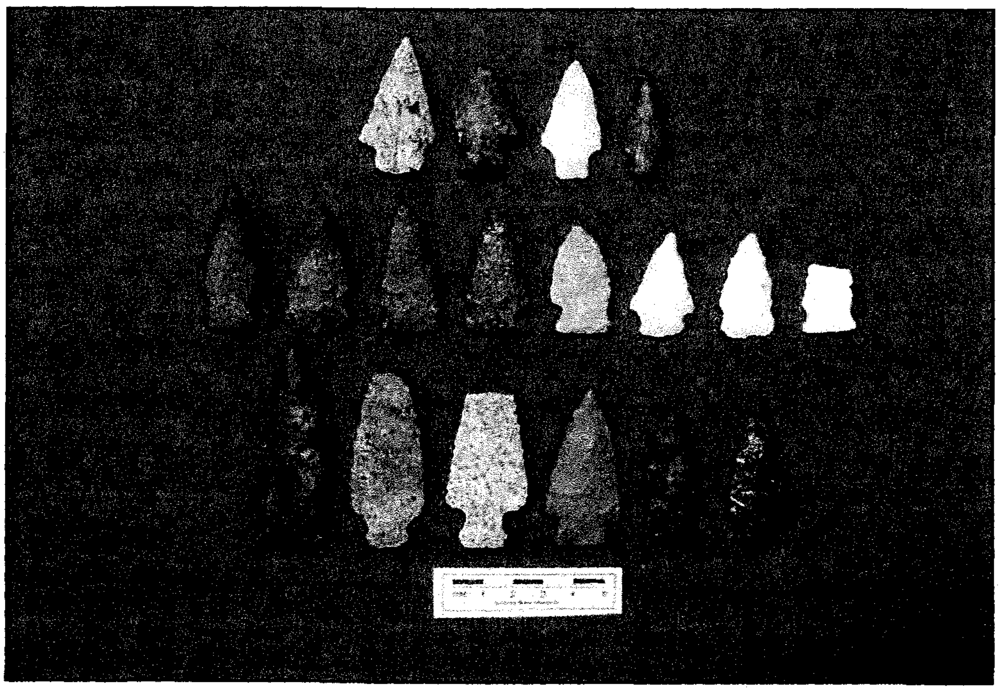


Figure 2.13. San Pedro phase projectile points from La Playa (Ochoa 2004).

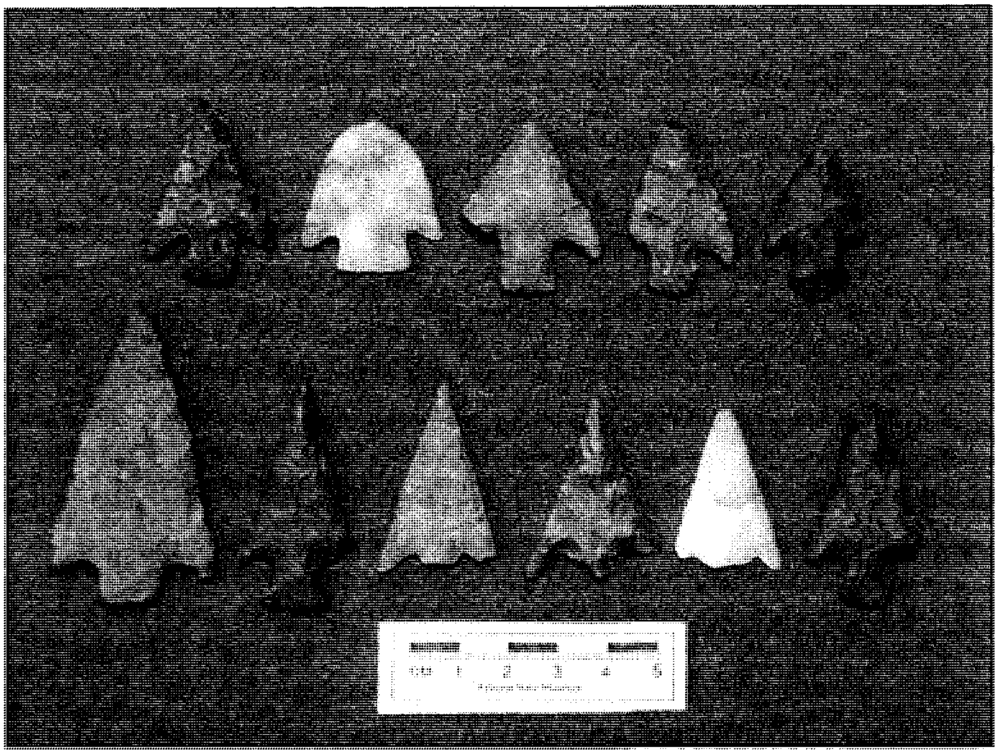


Figure 2.14. Cienega phase projectile points from La Playa (Ochoa 2004).

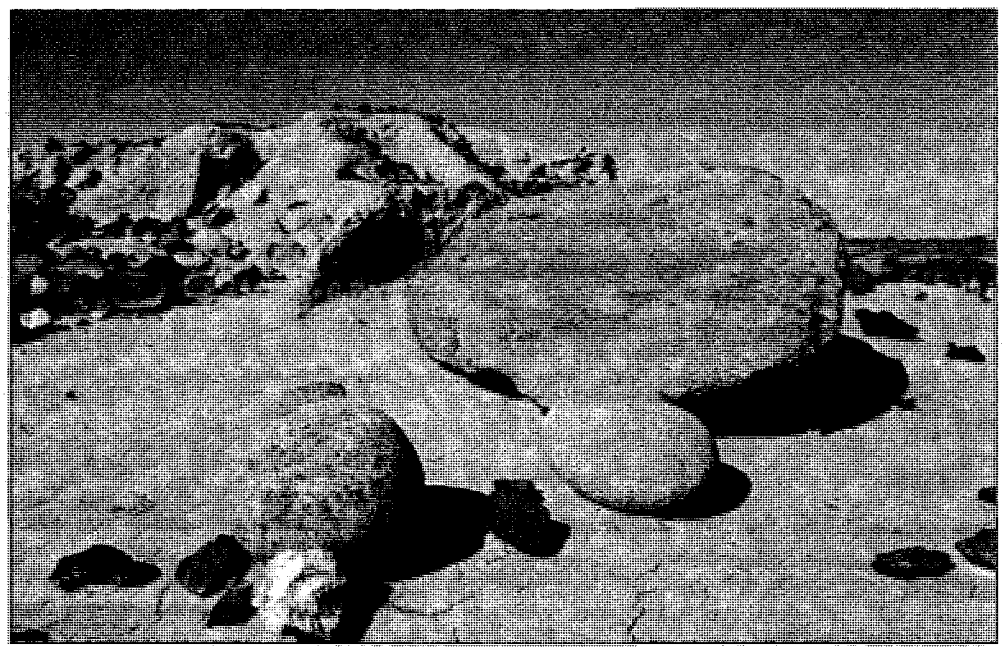


Figure 2.15. Ground stone on La Playa site surface (photo by David Becker 2007).

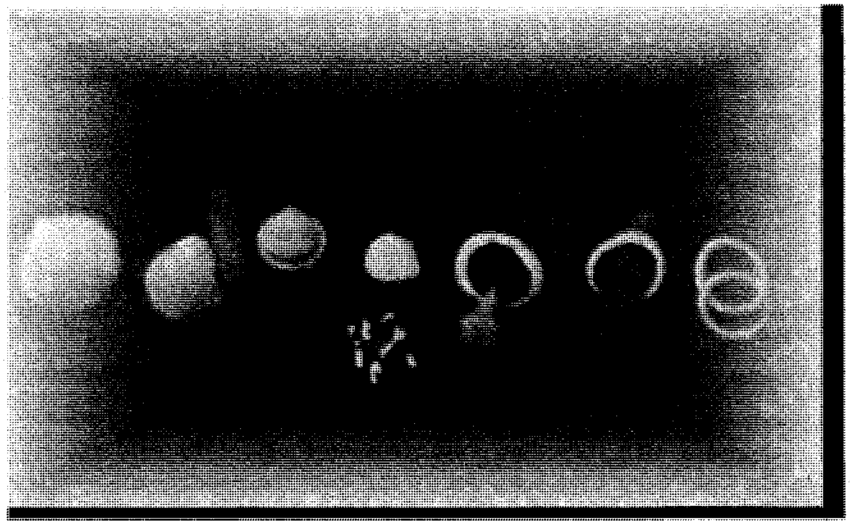


Figure 2.16. Shell jewelry artifacts with processing tools (from Carpenter & Villalpando 2002).

The question as to why prehistoric groups chose to adopt agriculture has been explored by many researchers (Diehl 2005; Huckell 1995; McClelland 2005; Roth 2006; Roth & Freeman 2008; Wills 1988; Wills & Huckell 1994). According to Wills (1988), the incorporation of cultigens into a subsistence economy signals a change in the relationship between a population and their local environment. For example, Hard and colleagues (1996) argue that caring for even a small maize crop would necessitate changes in residential mobility. Wills (1988) associates the adoption with the need to reduce risk and environmental unpredictability. In the relative abundance of the Sonoran Desert, Roth (1996) suggests that cultigens were part of a strategy that included storage for lean times. Watson (2005) suggests that, at La Playa, incorporating cultigens into a mixed-economy indicates a pattern of amplified food collection and processing that allowed for more effective use of floodplain resources (after Wills & Huckell 1994).

La Playa was the focus of Watson's (2005) University of Nevada, Las Vegas (UNLV) dissertation and his dental database from the La Playa sample provided the data source used in this study. Watson examined a dental sample (n=157) focusing on ten attributes of dental health correlated with subsistence practices to test the hypothesis that maize dependence increased in the Sonoran Desert during the Early Agricultural Period. Although results failed to support this premise, analyses provide insights into the diet, behavior and dental health of La Playa inhabitants (Watson 2005, 2006). Dental data provide evidence of sex-specific variation, which Watson suggests may have been the result of dietary differences between La Playa men and women. He argues that gender-based social divisions emerged as food processing intensified to feed a growing population (Watson 2005).

In discussing diet, dental health and subsistence, Watson (2005, 2006) observed that the population, with a mean caries frequency of 13.46%, is more in-line with fully committed agriculturalists. Research into population frequencies have established average caries rates broken down by economy. Turner found that hunter-gatherers have the lowest incidence of caries (frequently less than 2%), a mixed-economy results in slightly higher rates with a mean approximating five percent, and agriculturalists exhibit the highest percentages for caries usually higher than 10% (variation ranges between 2 to 26.9%) (Scott & Turner 1988; Turner 1979). The wide range of frequency rates indicates that there are factors in addition to diet that affect the etiology of dental caries (e.g., sex-based physiology, sociocultural influences that affect access to resources).

Watson (2005:87) cites skeletal analyses by Ethne Barnes in 2003, which identified health indicators for the La Playa population. In general, the skeletons demonstrate little evidence of infectious disease or developmental pathologies and stature is relatively tall (based on a sub-sample of 18, the females ranged from about 150 cm to 165 cm and males ranged between 159 cm to 173 cm) (Watson 2005:88). The long bones of both males and females are slender and Barnes found no evidence of sex-based variation in muscle attachment sites. The health and stature of the population are indicative of a mixed-subsistence diet that provided the nutritional balance and variety needed for proper growth and development (Watson 2005). Watson (2005:186) found that oral health at La Playa remained relatively stable from the San Pedro through the Cienega phase, with no statistically significant difference in dental pathology rates during the course of the Early Agricultural Period.

Barnes found incidence of cribra orbitalia (porotic hyperostosis of the orbits) in 5 out of 28 individuals (18%) from a sub-set of two females, two males and one sub-adult (Watson 2005). The characteristic pitting of the upper orbitals indicates episodes of iron-deficiency anemia during childhood development. Barnes also recorded one female who exhibited signs of tuberculosis infection in her hip. A small number of individuals had evidence of degenerative joint disease (DJD), even though demographics indicate numerous individuals lived beyond 45 years of age (Watson 2005).

Methodology

The methods used in this study are based on the premise that the dentition of archaeological populations can provide insights into health, diet, economy, behavior and environment (Scott & Turner 1988). The relationship between subsistence and oral health has been well documented in the literature, primarily through the study of dental caries. For example, a pattern of sex-based differences in caries rates has been recognized in early agricultural populations, which indicates that women were impacted more negatively than men. Previous research has shown that the La Playa diet included cariogenic carbohydrates such as maize and local resources (e.g., cactus) (Watson 2005; Watson et al. 2006; Watson 2008). Therefore, to investigate the possible affects from hormonal fluctuation on Early Agricultural women at La Playa, caries and AMTL data for the sample's adult men and women were examined.

The La Playa archaeological and skeletal collections are maintained by the *Centro Instituto Nacional de Antropología e Historia* (INAH) and housed at the *Biblioteca y Museo de Sonora* in Hermosillo, México. As part of this study, in March of 2007 using the laboratories at Hermosillo, dental data were collected from forty-seven burials excavated from La Playa (Figure 2.17). The data were added to the La Playa master database previously assembled by Watson in a Microsoft Excel spreadsheet. The study sample (*n*=142) was then drawn from the master database and sample data were imported to SPSS software for analyses. The analyses examine caries and ATML rates for reproductive-age women and age-matched men.

To maintain consistency in La Playa's database, standardized dental recording codes (Appendix B) and dental analysis recording forms (Appendix C) were developed by Watson (2005) and were used to record dental observations (after Buikstra & Ubelaker 1994). Dental observations and inventory were made on dental development, abscesses, calculus, caries, chipping, hypoplasias and opacities, periodontal disease, tooth wear and attrition angle. With this information, the La Playa database can be used to statistically explore variables, such as sex and age group.

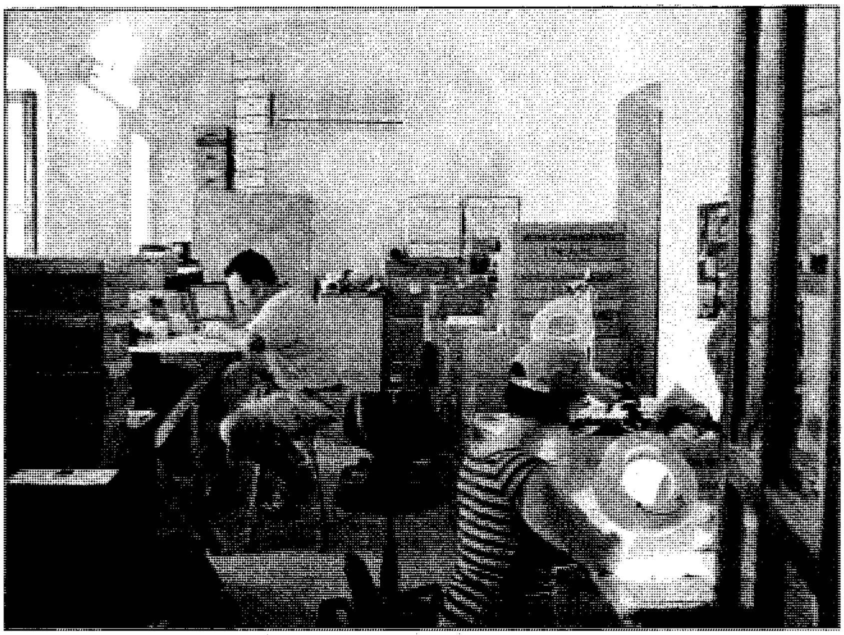


Figure 2.17. Data collection in the laboratory at *Biblioteca y Museo de Sonora* in Hermosillo (photo by M. Fields).

Buikstra and Ubelaker (1994) recommend a recording system for dental inventory that assigns numbers 1 to 32 to the permanent dentition and numbers 51 to 70 for deciduous teeth (Figure 2.18). Use of this numbering method ensures that each tooth for every individual has a specific number, preventing confusion when entering data. As a result, the dentition of each individual in the burial assemblage can be independently evaluated. This quantification permits calculation of the number of teeth present or absent, prevalence of dental disease, dental attrition and so on. The criteria permit analysis of sub-groups by sex or age category, which assists in understanding caries and AMTL occurrence at La Playa.

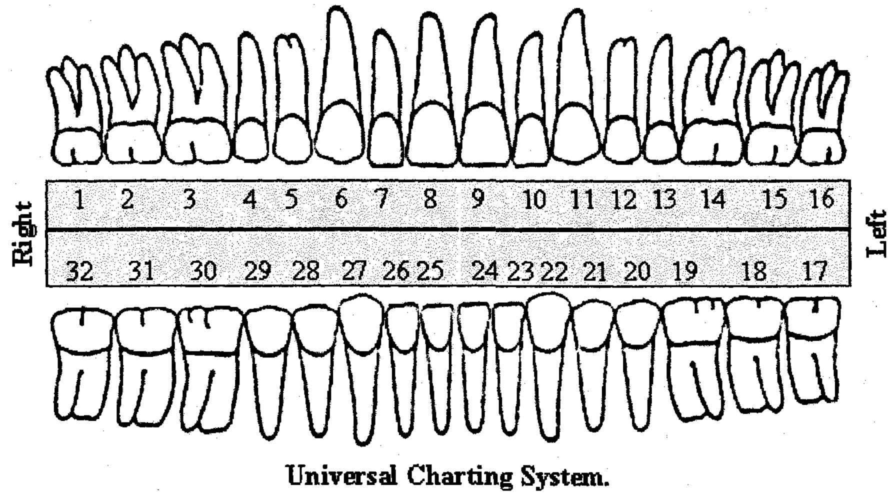


Figure 2.18. Dental Numbering System (Buikstra & Ubelaker 1994).

The development of dental caries is multifactorial, with specific conditions that are necessary for cariogenesis. Contributing factors include a diet of fermentable carbohydrates, susceptible tooth surfaces, and the presence of cariogenic bacteria (e.g., *Streptococcus mutans, Staphylococcus*) (Hillson 1996; Powell 1998). During fermentation of food particles that are trapped on tooth surfaces, salivary pH increases in acidity, creating an environment favorable to oral bacteria. Therefore, the type of foods eaten can facilitate caries formation, and carbohydrates and simple sugars are especially problematic as they adhere more readily to tooth surfaces and ferment rapidly (Hillson 1996).

Factors that can contribute to the loss of teeth during life include caries, periodontal disease, trauma, dental wear and attrition, and cultural practices (Hillson 1996; Turner 1979). Antemortem tooth loss among hunting and gathering societies with "low caries rates, moderate wear and limited periodontal disease" is infrequent, while, according to Scott and Turner (1988:116), tooth loss among agricultural groups is elevated "due to caries and rapid wear". A tooth is exfoliated when advanced decay and degenerative processes result in the loss of gingival and alveolar support of the dental structure in the periodontal membrane (Hillson 1996). In archaeological populations, AMTL is identified macroscopically by "alveolar bone resorption and socket filling" (Turner 1979:621).

Susceptibility to dental caries also varies by tooth type, based on dental morphology. For example, caries occurrence is often greater in posterior (premolars and molars) teeth versus anterior (incisors and canines) teeth (Erdal & Duyar 1999). Typically, caries occur most frequently on molars, then premolars, incisors and lastly canines. Molars are particularly susceptible because of the complex occlusal surface (Hillson 1996). In addition to differences in caries susceptibility during life, classes of teeth differ in postmortem preservation. According to Erdal and Duyar (1999), incisors and canines are disproportionately lost following deposition due to tooth morphology and the anatomical structure of the roots. With a single tooth root, anterior teeth are lost more often than posterior following deposition. To address such discrepancies in archaeological populations, Erdal and Duyar (1999) suggest grouping teeth by anterior and posterior classes; a method included in this study's analysis of caries and AMTL.

There are additional factors, such as mineral content (e.g., fluoride) in the water supply or dietary grit, which are known to have a modifying effect on the dental health of populations. These factors were discussed by Watson (2005) in his dissertation and are re-examined in the discussion section of this study.

Data Collection

Data collection included macroscopic assessment for the presence or absence of dental pathologies. Carious lesions were recorded only where decay of the tooth surface(s) or root(s) was observed (Figure 2.19). When necessary to aid in caries identification, a magnifying glass and dental probe were utilized. The following were recorded for each carious lesion observed: the location of the tooth in the dental arch (maxilla or mandible), the specific tooth affected (incisor, canine, premolar or molar), and the initiation site or tooth surface(s) involved (occlusal, interproximal, buccal, lingual, cemento-enamel junction, root) (refer to Appendixes B and C).

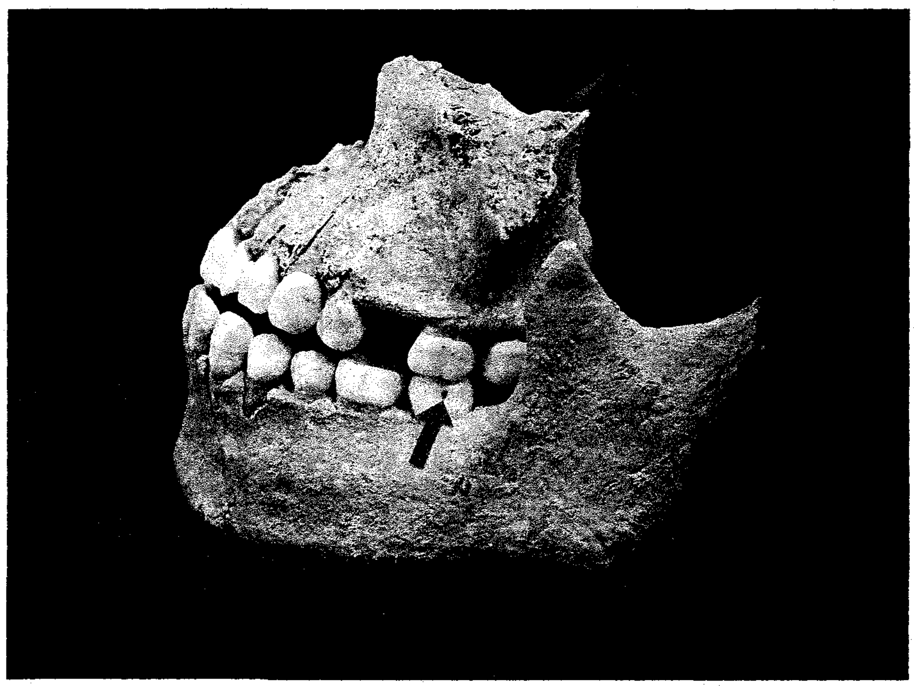


Figure 2.19. This female (Burial 431) exhibits a carious lesion on the buccal surface of the mandibular second molar. (Photo courtesy of J. Watson).

Antemortem tooth loss was recorded only when alveolar bone remodeling with either partial or complete alveolar resorption was observed (Figure 2.20). If the alveolar socket was open, tooth loss was recorded as postmortem (Figure 2.21). Problems can arise with this method in assessing AMTL because teeth lost near or at the time of death will be recorded as postmortem loss. Lukacs (1995) suggests, however, that problems in the interpretation of AMTL due to this type of error are likely negligible. When neither the tooth nor alveolar segment was present, the dental code records the tooth as missing with no associated alveolar bone (not as postmortem loss). This method reduces interpretive problems where AMTL is recorded in lieu of postmortem tooth loss, thereby inflating pathology rates. A summary of the dental data for caries frequency is presented in Table 3.1. Antemortem tooth loss data are presented in Table 3.2.

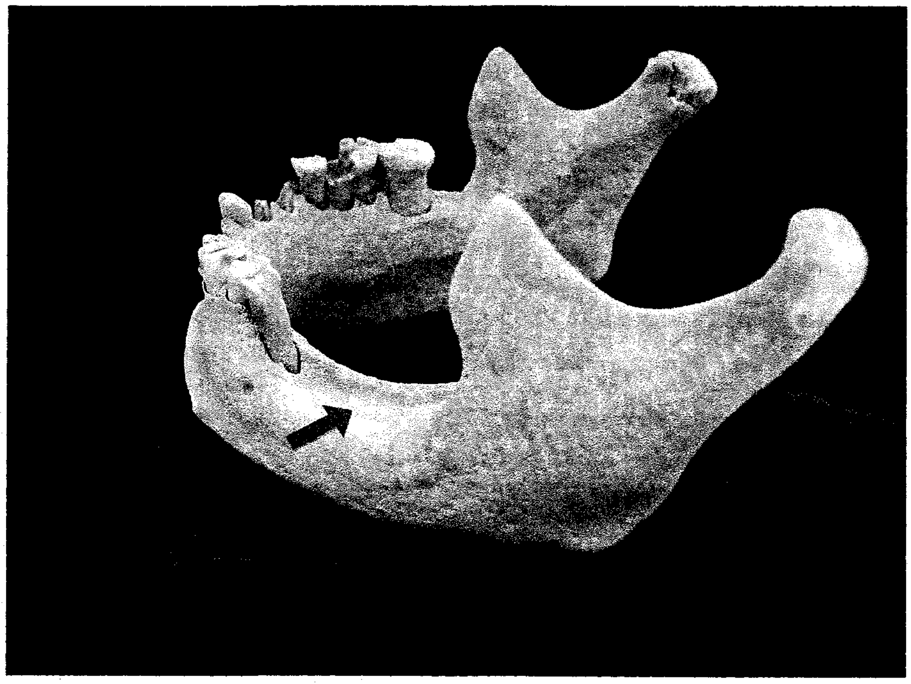


Figure 2.20. Photo of female (Burial 208) exhibiting alveolar bone remodeling on mandible (Photo provided courtesy of J. Watson).

Figure 2.21. Photo of female (Burial 366) exhibiting open socket on maxillary premolar with no evidence of resorption. On the mandible, bone remodeling is seen where second molar is missing (Photo provided courtesy of J. Watson).

Age categories for the sample used in this study were assigned as follows: 15-24 as young adults (*n*=15), 25-34 as adults (*n*=35), 35-44 as mature adults (*n*=48) and 45-55 (*n*=44) as nearing or already post-reproductive (peri- or post-menopausal). The break down by sex for each category is as follows: young adults included 8 females and 7 males; the adult category had 15 females and 20 males; mature adults totaled 25 females and 23 males, and the group at reproductive cessation had 23 females and 21 males.

Descriptive statistics summarize the raw data in frequency tables and statistical tests aid in identifying patterns that help build inferences about La Playa inhabitants. Statistical results are presented in Chapter Three. Statistical tests were performed using SPSS 14.0 Student Version for Windows.

CHAPTER THREE

ANALYSIS AND RESULTS

Fieldwork at La Playa has yielded a skeletal sample that is evenly distributed between demographic variables and location within the site (Watson 2005). Analysis by Montero (cited in Watson 2005:132) found no identifiable patterns relating to burial treatment or placement within the site. The excavated inhumation burials have provided radiocarbon dates that cover the Early Agricultural period (1600 B.C. to 200 A.D.). As such, the La Playa burial assemblage can be treated as a random sample of site inhabitants, whose remains were deposited during, and are therefore representative of, the Early Agricultural period.

The most important aspect of the La Playa burial sample, for purposes of this study, is that it is well suited for analyses addressing the impact of the transition to agriculture on dental health. In addition, the teeth from the La Playa sample tend to be well preserved and in good condition. Recorded observations for the sample resulted in quantitative data that was analyzed for statistically significant patterns relating to the dental health of the adult women and men at La Playa.

Applying the Central Limit Theorem, it can be assumed that the La Playa skeletal collection (N=256) from which the sample for this study is derived, is normally distributed. This theorem is a function of sample size and provides that, given a sample size greater than thirty (n>30), the sample means will tend toward a normal probability distribution. Quantitative variables include frequency counts for the total number of teeth in the sample and dental observations of both caries and antemortem tooth loss (AMTL). The analyses attempt to identify differences in the occurrence of dental pathologies when grouped by independent variables that include sex, age category and presence or absence of grave goods. Individuals in the study sample are not differentiated according to chronological horizon due to the large number of burials (*n*=122) from unidentified archaeological phase (i.e., San Pedro or Cienega).

The sample (*n*=142), by chance, included an equal number of males to females ranging in age between 15 and 55 years. The database provides information from the 71 females and 71 males regarding burial number, sex, age group, grave goods, number of teeth recovered, caries and AMTL data (refer to Appendix A). Individuals 15 years and older were included as they would have been near or of reproductive age. By 55 years of age, most women would have been post-menopausal. Excluding individuals older than 55 reduced sample bias related to tooth loss from senescence. Therefore, the age range from 15 to 55 provides a sample that spans pre-reproductive, peak-reproductive and post-reproductive.

Frequency Rates

The analysis of dental caries and AMTL in archaeological populations has been used to examine the impact of changes in cultural behavior (i.e., subsistence and diet) on dental health. In general, research has demonstrated a strong correlation between diet, subsistence, and dental disease. The etiology of dental caries is multifactorial as it relates to the interaction between diet, oral health, and bacteria (i.e., *Streptococcus mutans*).

Additional factors that can affect cariogenesis include mineral content (i.e., fluoride) present in the soil or water supply and the amount of grit in the diet. Antemortem tooth loss, which is highly age related, provides an indication of overall health as it relates to declining oral conditions and the progression of dental disease.

This study employs standardized frequency calculations for caries and AMTL rates to assess the sample as a whole and by sex (Buikstra & Ubelaker 1994; Lukacs 1989, 1995). The use of several formulas provides various ways of examining differences between groups (Lukacs 1995). Table 3.1 displays caries data using three frequency calculations. The individual frequency rate provides information as to the prevalence of dental caries. The individual caries frequency rate is calculated by dividing the number of individuals affected with caries by the total number of individuals for each grouping. A second frequency calculation provides the average number of caries per individual, listed as the number of carious teeth per mouth (Lukacs 1989, 1995). This formula describes the severity of dental caries for the individuals in the sample and is calculated by dividing the total number of carious teeth by the total number of individuals. Thirdly, the formula for the observed caries rate divides the number of carious teeth by the total number of teeth observed. The observed caries rate describes the percentage of caries for each group based on the number of teeth present.

Caries Frequency Calculations

1) Individual Frequency Rate: $\frac{\text{\# of individuals with caries}}{\text{total \# of individuals in the group}}$

2) Carious Teeth per Mouth: $\frac{\text{\# of teeth affected with caries}}{\text{total \# of individuals in the group}}$

3) Observed Caries Rate: $\frac{\text{\# of teeth affected with caries}}{\text{total \# of teeth in the group}}$

The data presented in Table 3.1 shows that, of the total sample (*n*=142), 60.6% of individuals had at least one carious tooth with an average of 1.76 carious teeth per mouth. La Playa women had slightly higher individual caries frequency rates (63.4%) than the men (57.7%). This finding suggests that among adult men and women at La Playa, there were more women in the sample with caries compared to men. However, the men exhibited more carious teeth per mouth than the women (1.89 versus 1.64 respectively). A plausible explanation for this variation would be that the women had less carious teeth present per mouth because they were losing more teeth (refer to Table 3.2). With the high AMTL exhibited by the females in the sample, caries frequency rates likely do not present an accurate description of the full impact caries had on adult women at La Playa.

Table 3.1. Summary of Dental Caries Frequencies for La Playa sample (*n*=142)

Variable: Caries	Sample (*n*=)	Individuals w/ Caries (*n*)	Carious Teeth (*n*)	Total # of Observed Teeth (*n*)	Individual Caries Rate	Carious Teeth per Mouth (*n*)	Observed Caries Rate
Males	71	41	134	1099	57.7%	1.89	12.1%
Females	71	45	116	1127	63.4%	1.64	10.3%
Total	142	86	250	2226	60.6%	1.76	11.2%

Antemortem tooth loss data, presented in Table 3.2, is shown by tooth count (reported as intensity), by individual frequency rate and by AMTL per mouth (Lukacs 1989). Antemortem tooth loss by tooth count describes the severity of AMTL for each group. This formula is calculated by dividing the total number of AMTL by the total number of observed teeth. Individual AMTL frequency is calculated by dividing the total number of individuals exhibiting AMTL by the total number of individuals in each group. The formula for AMTL per mouth is calculated as the total number of AMTL divided by the total number of individuals in the group, which provides an average number of teeth lost per mouth for each group.

In addition to the standard calculations used to describe AMTL, Powell (1988:115) suggests reporting pooled caries and AMTL counts as combined frequency rates by adding the number of carious teeth to the number of teeth lost premortem and dividing this sum by the total number of teeth observed. Counts and frequency rates for the combined pathologies are presented in Table 3.2. Powell (1988) suggests that these values demonstrate the magnitude of the combined dental pathologies, which for the sample indicate that females (33.6%) were impacted to a greater degree than males (24.4%).

AMTL Frequency Calculations

1) AMTL Intensity Rate: $\frac{\text{\# of AMTL in the group}}{\text{total \# of observed teeth in the group}}$

2) Individual AMTL Frequency: $\frac{\text{\# of individuals with AMTL}}{\text{total \# of individuals in the group}}$

3) AMTL per mouth: $\frac{\text{\# of teeth lost antemortem}}{\text{total \# of individuals in the group}}$

4) Combined Pathology Rates: $\frac{\text{Sum \# of carious teeth and \# AMTL}}{\text{total \# of observed teeth in each group}}$

The incidence of AMTL at La Playa affected 47.9% of the sample of adult men and women. Females exhibit slightly higher individual frequency (49.3%) than males

(46.5%). But the intensity value, which indicates the number of teeth lost antemortem, was far greater for females (23.3%) than for males (12.2%). Among women, the number of teeth lost antemortem per mouth was also nearly double (3.7) than that for men (1.89).

Table 3.2. Summary of AMTL rates for La Playa sample (*n*=142)

Variable AMTL	Sample (*n*=)	Indvdl. with AMTL (*n*=)	AMTL (*n*)	Observed Teeth (*n*)	AMTL Intensity	Individual AMTL frequency	AMTL per mouth	Sum of Caries & AMTL	Caries & AMTL rate
Males	71	33	134	1099	12.2%	46.5%	1.89	268	24.4%
Females	71	35	263	1127	23.3%	49.3%	3.70	379	33.6%
Total	142	68	397	2226	17.8%	47.9%	2.80	647	29.1%

A chi-square test was performed to identify the association between caries frequency and sex found no statistical significance between variables (x^2 =.186, alpha level = .05, d.f. = 1, x^2 critical = 3.841). These findings might initially suggest that for early agricultural men and women at La Playa, there was no relationship between caries and sex. However in archaeological populations, caries rates are known to be affected by the number of teeth lost antemortem, a percentage of which are lost due to carious decay.

Results from a chi-square test on AMTL frequency rates indicates a strong relationship exists between AMTL and sex, even at the .01 significance level (x^2 = 41.9, alpha level = .01, d.f. = 1, x^2 critical = 6.635). These values suggest that AMTL impacted the health and lives of La Playa women to a considerably greater degree than La Playa men.

In addition to comparing sample frequency counts by sex, frequency rates also permit comparison of the total sample with the La Playa population, in which Watson (2005) recorded a caries rate of 6.9% for La Playa males (n=142), while females (n=93) had slightly less caries frequency at 4.5%. Antemortem tooth loss rates, however, confirmed that tooth loss was much greater for females (n=198) at 16.4% compared with males (n=120) at 8.4% (Watson 2005).

Caries Correction Formulas

Since a positive correlation between caries and AMTL has been recognized, Lukacs suggests the use of a 'caries correction formula' (Lukacs 1995). According to Lukacs, this correction is important in analyzing the dental health of populations where AMTL is high. Such is the case at La Playa, where Watson (2005) documented slightly greater caries rates for the men, while a high frequency of AMTL was recorded for the women. This study re-examines Lukacs' correction formula to determine its effectiveness in assessing the impact of caries and tooth loss on dental health.

To calculate Lukacs' formula, frequency counts for the number of teeth lost antemortem, the number of carious teeth, and the number of teeth with carious pulp exposure and exposure due to attrition (non-carious pulp exposure) must be known (Lukacs 1995). The formula implies that the loss of teeth during life is limited to dental caries or attrition, thus minimizing additional causes such as periodontal disease or trauma. While the formula is an attempt at compensating for teeth lost from carious decay, problems related to inflation of caries rates might arise (Erdal & Duyar 1999).

In addition, the caries correction formula does not account for the problem of postmortem tooth loss. Erdal and Duyar (1999) developed a 'proportional correction factor' to address differential preservation of teeth postmortem. The procedure uses fractions derived from the human dental formula (three anterior teeth and five posterior teeth per upper or lower side), which gives a ratio of 3:5 for anterior to posterior teeth. To calculate the formula, the anterior teeth are multiplied by three-eighths and the posterior teeth by five-eighths. Erdal and Duyar (1999:237) suggest the use of this procedure along with Lukacs' correction formula provides a way to approach "an almost true caries prevalence".

According to Erdal and Duyar (1999, 2003), anterior teeth are not affected by caries to the same degree as posterior teeth. In addition, anterior teeth are lost in greater numbers post-deposition. The authors suggest that the difference to disease susceptibility and tooth preservation by tooth class results in a distortion in "caries frequency… from its real value" (Erdal & Duyar 2003). To reduce discrepancies in reporting caries frequency based on total counts, sample data for dental pathology (i.e., caries and AMTL) was organized by sex and tooth class (i.e., anterior and posterior teeth) and frequency counts were conducted. Anterior teeth include incisors and canines (tooth numbers 6 through 11 and 22 to 27). Posterior teeth include premolars and molars (tooth numbers 1 through 5, 12 to 21 and 28 to 32). Lukacs' caries correction formula (1995) was then applied by tooth class (per Erdal & Duyar 2003).

As proposed by Lukacs (1995), the caries correction formula requires counts for the number of teeth lost antemortem from pulp exposure to be organized by etiology (caries-induced pulp exposure and non-carious pulp exposure). Dental recording code number six (described as "large cavities that destroyed so much tooth surface that no surface of origin can be determined") and code number seven (described as "non-carious exposed pulp chamber") were used (refer to Appendix B). The dental recording codes used for data collection restricted the ability to classify caries-induced pulp exposure. Therefore values used to calculate the correction formula may not provide an accurate account of the proportion of teeth with caries-induced pulp exposure. The data are presented in Table 3.3. The use of the correction formulas did not provide statistically significant changes in caries rates.

Analysis of Differences by Sex

The statistical analyses for this study were done to explore caries and AMTL rates for the sample (*n*=142) of reproductive-aged La Playa females (*n*=71) and age-matched males (*n*=71). Descriptive statistics are displayed in Table 3.4. The mean and median are used as a measure of the sample central tendency, while the sample standard deviation and coefficient of variation provide a measure of data dispersion (Table 3.4). Using a variety of measures to explore data helps prevent the loss of relevant information (Harry, personal communication, 2007).

The mean is calculated as the average of the data set, while the median is the middle value of the data range. The mean has mathematical properties that lend itself to analysis and the median is useful because it is not influenced by extreme values. The sample standard deviation, calculated as the square root of the variance, allows comparison between the data dispersion of two or more groups (Madrigal 1998). The formula for the coefficient of variation divides the standard deviation by the mean. This value can also be multiplied by 100 to convert to a percentage, but for this study the coefficient of variation is reported as a numeric value, as is the standard deviation. This figure is useful when comparing groups with different means because it compares relative values, rather than absolute values.

Table 3.3. Data for caries correction formula.

Frequency counts and rates	Anterior Females	Anterior Males	Posterior Females	Posterior Males	PCF %
a) Number of Observed Teeth (*n*)	411	391	716	708	
b) Number of Carious Teeth (*n*)	19	16	97	118	
c) Uncorrected Caries Frequency Rate (%)	4.6	4.1	13.5	16.7	
d) Proportional Caries Frequency Rate (%)	1.73	1.54	8.44	10.44	
e) Number of AMTL (*n*)	58	25	205	109	
f) Teeth w/Caries-induced Pulp Exposure (*n*)	0	2	15	19	
g) Teeth w/Non-carious Pulp Exposure (*n*)	74	57	53	52	
h) Caries Frequency Rate following Lukacs correction formula (%)	4.05	4.05	15.45	18	
i) Females Caries Frequency after PCF	-	-	-	-	8.4%
j) Males Caries Frequency Rate after PCF	-	-	-	-	11%

a) Tooth count by Recording Codes P/A #1, #2, #7, #8, #9

b) Carious tooth count Recording Codes Caries #1 through #6

c) Calculated by dividing b by a

d) Calculated by multiplying c by 3/8 (.375) for anterior and 5/8 (.625) for posterior

e) AMTL count by Recording Code P/A #4

f) Caries-induced pulp exposure count by Recording Code Caries #6

g) Non-carious pulp exposure count by Recording Code Caries #7

h) Lukacs Caries Correction formula adjusting for AMTL

i and j) Proportional Correction Factor (PCF) as per Erdal & Duyar (2003)

Since the coefficient of variation expresses the standard deviation as a relative value, this measure is used to describe AMTL data dispersion for La Playa men and women. The coefficient of variation for caries for females (1.22) and males (1.41) was close to the sample coefficient of variation at 1.33. These values indicate that caries data for women deviated slightly less around the mean, compared to data for men, which was slightly above the caries data dispersion for the sample. The data dispersion for AMTL was again greater for La Playa males at 1.65 compared to females at 1.57, while the sample coefficient of variation measure 1.69. Overall, the data for caries and AMTL for La Playa women exhibit less dispersion around the mean than the data for men do.

Data trends were assessed for statistical significance in light of the research questions and objectives of this study. By exploring patterns in the data, statistical analyses permit the investigation of relationships between independent variables (i.e., sex and age categories) and dependent variables (i.e., rates of dental caries and AMTL). In addition to testing for statistically significant differences between variables, the strength of the relationship(s) between variables was tested using effect tests.

The frequency table (Table 3.5) summarizes raw counts of dental caries and AMTL. The sample mean for caries is 1.76, which is the same as caries occurrence per mouth shown in Table 3.1. The sample median for caries was 1.0, which indicates that there were as many individuals with no caries as there were individuals with one or more caries. The frequency of AMTL, with a mean of 2.8, was much higher than for dental caries. This same figure can be calculated using the total number of teeth lost antemortem divided by the number of individuals in the sample (see Table 3.2.) This value might be taken to imply that most individuals in the sample were nearly three teeth during their lifetime. However the median value of zero for AMTL indicates that there were a number of individuals who did not loose any teeth antemortem. The sample standard deviation for caries measures 2.3 and for AMTL, it is 4.7.

Table 3.5 summarizes descriptive statistics for the data organized by sex. The mean for caries for La Playa women is 1.6 and for the men, 1.9. Standard deviation for the women is just under two (1.98) and for the men, it is 2.66. The mean for AMTL, however, is much greater for females at 3.7 with a standard deviation of 5.8. The men at La Playa had an AMTL mean equal to the mean for caries (1.9), however the standard deviation of 3.2 is slightly greater for AMTL. The values for standard deviation for both men and women indicate that some individuals in the sample were affected considerably by tooth loss.

Table 3.4. Central tendency and data dispersion

		CARIES (n)	AMTL (n)
N	Valid	142	142
	Missing	0	0
Mean		1.76	2.80
Median		1.00	.00
Std. Deviation		2.346	4.733
Variance		5.503	22.405
Skewness		2.045	2.688
Std. Error of Skew		.203	.203
Kurtosis		5.669	9.480
Std. Error of Kurtosis		.404	.404
	25	.00	.00
Percentiles	50	1.00	.00
	75	3.00	4.00

Table 3.5. Mean, median and standard deviation for caries and AMTL by sex

Pathology	Sex	(n)	Mean	Std Deviation	Std. Error Mean	Median
Caries	Female	71	1.63	1.987	.236	1.00
	Male	71	1.89	2.665	.316	1.00
	Total	142	1.76	2.346		1.00
AMTL	Female	71	3.70	5.807	.689	.00
	Male	71	1.89	3.119	.370	.00
	Total	142	2.80	4.733		.00

Kolmogorov-Smirnov and Shapiro-Wilk tests for normality were used to examine the sample distribution. Results indicate that the data differ from a normal, symmetric distribution with skewness values showing a positively skewed dispersion (Table 3.6). A boxplot (Figure 3.1) of the sample by age category provides a visual graph of the data dispersion. The graph identifies outliers by burial number with individuals exhibiting extreme values labeled by an asterisk (see Appendix A). The red line inside each box indicates the 50th percentile, or median, for that group's distribution. The lower and upper hinges of the box borders mark the 25th and 75th percentile, respectively, for each distribution.

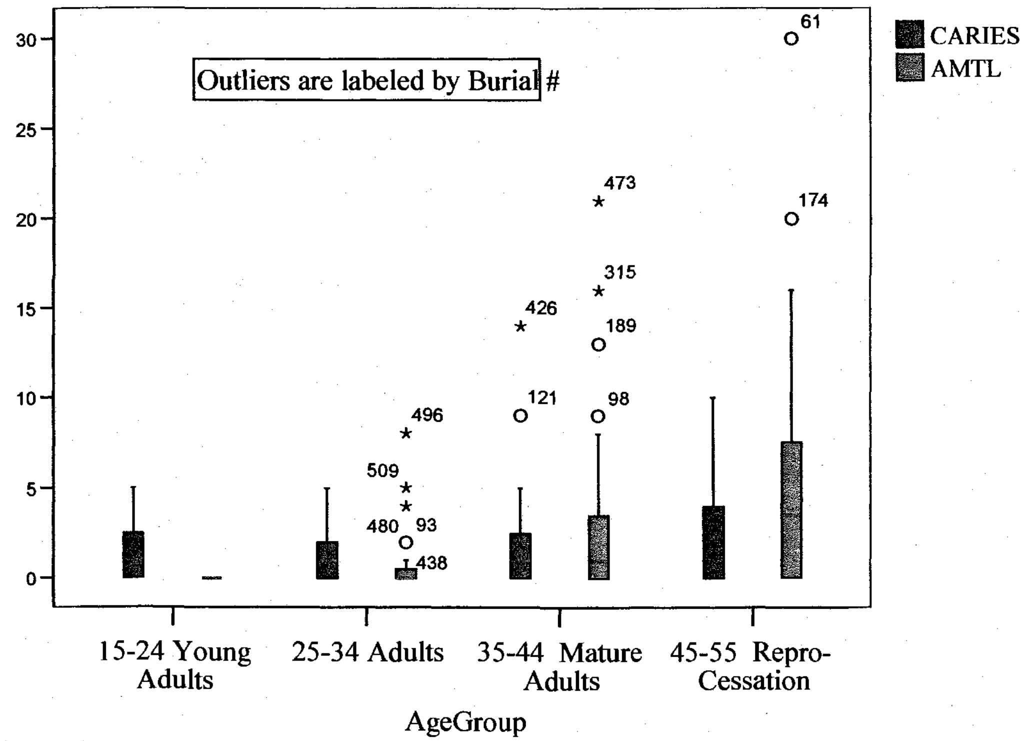
Data outliers are anticipated due to individual variation, since those who were more susceptible to the advance of dental decay would exhibit greater disease progression. Moreover, the boxplot demonstrates a predictable rise in the degree of dental pathologies with increased age. The combination of these factors results in the increase seen over time, accounting for the positive data distribution.

Table 3.6. Tests of Normality

	Kolmogorov-Smirnov(a)			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
CARIES	.268	142	.000	.752	142	.000
AMTL	.277	142	.000	.650	142	.000

a Lilliefors Significance Correction

Figure 3.1. Boxplot of Sample Data by Age Category



Although the sample distribution departs from normal, the Central Limit Theorem permits the use of parametric statistical tests with sample sizes greater than thirty (Harry 2007, Madrigal 1998). Parametric procedures were used to explore trends in the data, including unpaired *t* tests that compare means between two groups. In addition, non-parametric Chi-square and Analysis of Variance (ANOVA) tests were run.

Levels of significance help determine the validity of a sample as a proxy for a population, and the .05 significance level used for analyses in this study is conventional (Madrigal 1998). This significance level provides, with a 95% probability, that sample parameters (i.e., mean or median) will fall within the range of values indicated for the population (leaving a 5% probability that they would not). With the use of a .01 significance level, the probability rises to 99 percent. Confidence levels also signify that test results are not due to sampling error.

A two-sample independent *t*-test compared means for pathology rates between females and males to evaluate whether the differences observed between the groups are substantial enough to infer a real difference for the La Playa sample. The *t*-test is relatively insensitive to departures from normal, providing each sub-sample size is greater than thirty. The homogeneity of variances can be assumed because the two groups are of equal size. Tests were run individually for dental caries and ATML data.

Results from an independent *t*-test run on caries data indicate that there are no statistically significant differences in caries prevalence between females and males (alpha level =.05, *t*-value= -.64, d.f.=140, p=.522). The *p*-value (.522) indicates that there is more than a 50% probability that these two groups come from the same population. These results confirm the previous findings for caries frequency rates. An error bar graph (Figure 3.2) of caries data organized by sex shows where the true population mean is expected to lie, with 95% confidence. The error bar graph presents a visual display of the data showing that the males had slightly higher caries than the females. However, the data overlap considerably, which support the *t*-test findings that the differences are not statistically significant.

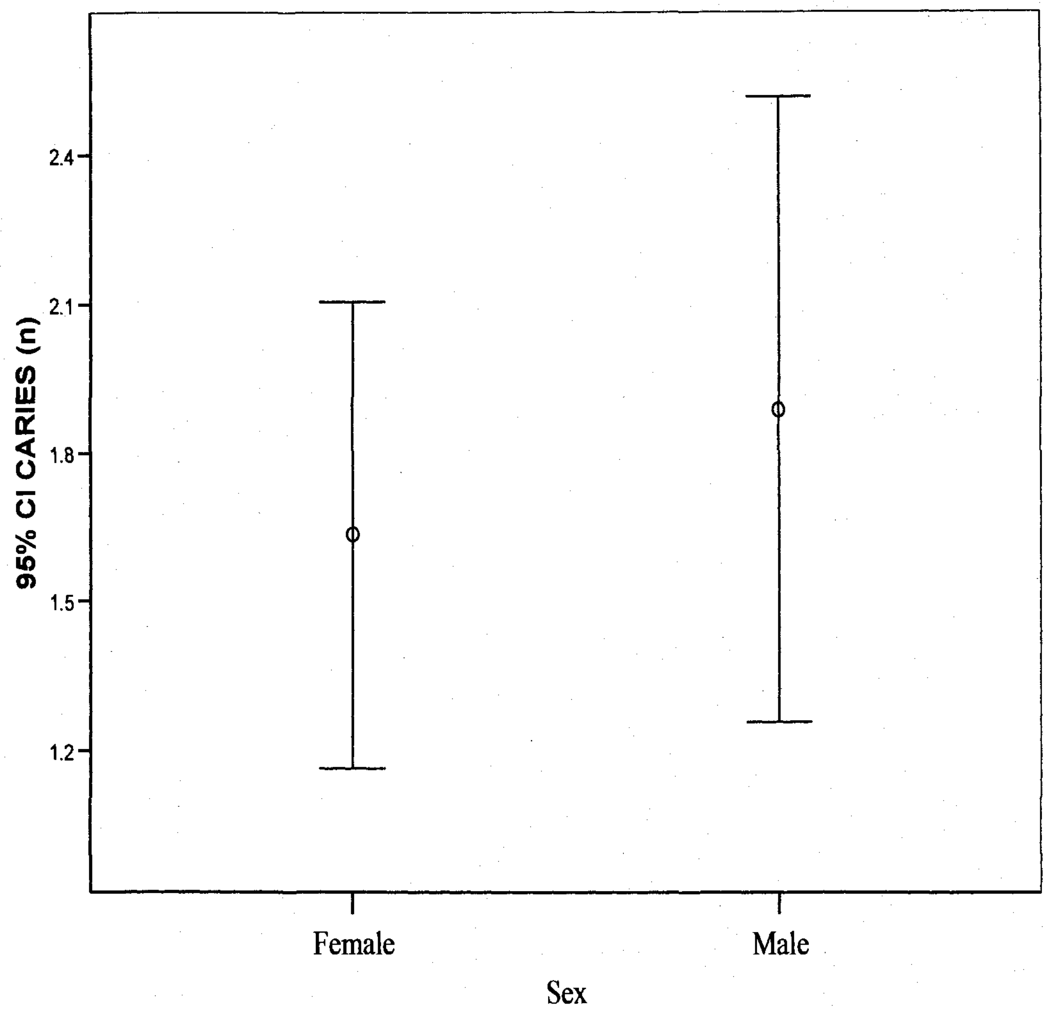


Figure 3.2. The error bar graph shows that males had slightly greater caries frequency than females, however, the data between the two groups overlap considerably. This overlap indicates that the difference between the groups is not significant.

Results from an independent samples *t*-test do confirm a statistically significant difference for AMTL rates between females and males, at the .05 level (*t*-value= 2.32, d.f.=140, p=.022). Furthermore, a Cohen's *d* test for effect indicates that there is a strong association between sex and AMTL (*d*=.39). The error bar graph of AMTL data (Figure 3.3) presents a visual representation of these differences with minimal overlap between group data. The markers on each bar indicate that the group means diverge considerably.

These findings suggest that AMTL was substantially greater among the reproductive-age women than men at La Playa.

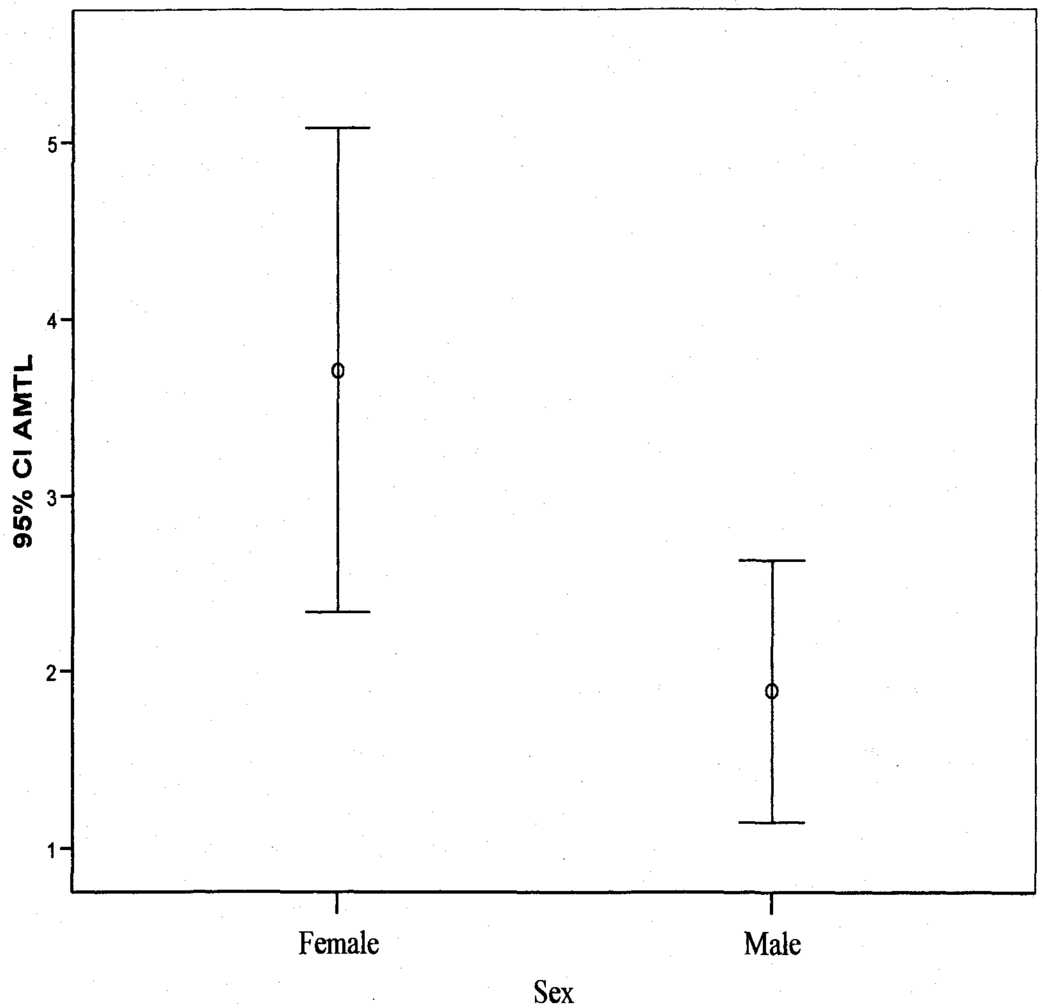


Figure 3.3. The error bar graph indicates that La Playa females had significantly greater tooth loss than La Playa males. There is almost no overlap between data distributions. The circle on each bar represents the sample mean. The circles in this graph indicate AMTL at La Playa diverged widely between the sexes.

The non-parametric alternative to the independent *t*-test, the Mann-Whitney *U* test, was used to compare sample medians. This test measures the extent to which two groups are separated based on the ranks of the sample data. The test is useful in confirming results from *t*-tests, but because it does not rely on distribution parameters, it cannot be used to make inferences about the population. The Mann-Whitney compares two samples (i.e., females and males) to test the probability that they come from the same population by ranking and comparing data observations (Harry, personal communication, 2007).

Only individuals exhibiting caries and AMTL of at least one or more were included in the analysis. Caries data included 45 females and 41 males, with a similar mean rank for both groups (Table 3.7). Table 3.8 presents results for caries, indicating that there is a 35% probability that the two groups come from the same population. A significance value greater than .05 indicates the difference between groups is not statistically significant (p = .350, alpha level =.05).

The Mann-Whitney test on AMTL data analyzed 35 females and 33 males, with a mean rank that diverged substantially (Table 3.9). Results provide a significance value of .007, which means that there is only a .7% probability at the .05 significance level that these two groups come from the same population (Table 3.10). These results validate and strengthen the findings from the *t*-tests.

Table 3.7. Summary of Caries Data by Sex

	Sex	N	Mean Rank	Sum of Ranks
CARIES (n)	Female	45	41.19	1853.50
	Male	41	46.04	1887.50
	Total	86		

Table 3.8. Mann-Whitney Test Results for Caries grouped by Sex

	CARIES (n)
Mann-Whitney U	818.500
Wilcoxon	1853.500
Z	-.935
Asymp. Sig. (2-tailed)	.350

a Grouping Variable: Sex

Table 3.9. Summary of AMTL data by Sex

	Sex	N	Mean Rank	Sum of Ranks
AMTL (n)	Female	35	40.79	1427.50
	Male	33	27.83	918.50
	Total	68		

Table 3.10. Mann-Whitney Test Results for AMTL data

	AMTL (n)
Mann-Whitney U	357.500
Wilcoxon W	918.500
Z	-2.717
Asymp. Sig. (2-tailed)	.007

a Grouping Variable: Sex

A Chi-Square Goodness of Fit test examines the proportion of cases from two groups to determine if observations differ significantly from previously determined expectations. This test was run on AMTL data to evaluate whether the observed frequencies of tooth loss depart significantly from what might be expected, given an equal probability of tooth loss for both women and men. The expected distribution of half the tooth loss from women and half from men assumes tooth loss is independent of physiological variables isolated by sex.

Residual values describe the difference between observed and expected frequencies (Table 3.11). The residuals indicate that the number of teeth lost for women is greater than expected, while the number of teeth lost for men is lower. A chi-square test (Table 3.12) found the differences statistically significant, even at the >.01 significance level (value obtained through Excel's CHIINV function). Results suggest that the amount of tooth loss experienced by adult women at La Playa was significantly greater than what would be expected ($x^2 = 41.92$, d.f.=1, N=397, p<.0005). In addition, these findings provide support for the argument that these women had disproportionately greater tooth loss than their male counterparts.

Table 3.11. AMTL Frequency by Sex

	Observed N	Expected N	Residual
Female	263	198.5	64.5
Male	134	198.5	-64.5
Total	397		

Table 3.12. Chi-Square Test Statistics on AMTL data

	Sex
Chi-Square(a)	41.917
Df	1
Asymp. Sig.	.000

a) 0 cells (.0%) have expected frequencies less than 5.

Changes across Age Categories

To investigate changes in dental health over the reproductive life of the adults at La Playa, an analysis of variance (ANOVA) was run comparing AMTL by age group. By comparing means (see Table 3.13), the ANOVA tests the probability that differences between groups have not occurred by chance. Since each age group (with the exception of the young adult group) is greater than 30 and sub-sample sizes are approximately equal, the Central Limit Theorem permits the use of a parametric ANOVA test. Data from the young adult age category was omitted from the ANOVA analysis, which does not impact results because the group exhibited virtually no AMTL.

Table 3.13. Descriptive Statistics Report for Caries and AMTL by Age Group

Age Group		Caries	AMTL
15-24 Young Adults	Mean	1.33	.00
	N	15	15
	StdDeviation	1.543	.000
	Median	1.00	.00
25-34 Adults	Mean	1.40	.71
	N	35	35
	StdDeviation	1.684	1.708
	Median	1.00	.00
35-44 Mature Adults	Mean	1.71	2.92
	N	48	48
	StdDeviation	2.633	4.505
	Median	1.00	1.00
45-55 Reproductive-Cessation	Mean	2.25	5.27
	N	44	44
	StdDeviation	2.651	6.036
	Median	1.00	3.50
Total	Mean	1.76	2.80
	N	142	142
	StdDeviation	2.346	4.733
	Median	1.00	.00

Results from a one-way ANOVA indicate that AMTL differs significantly (Tables 3.14 and 3.15) between age groups with age accounting for 17.1% of the variation in AMTL ($F= 9.475$, .d.f. =3/138, $p<.0005$, $eta^2 = .171$). This age-related increase is to be expected as AMTL is strongly correlated with age progression.

Table 3.14. ANOVA Test Results

			Sum of Squares	df	Mean Square	F	Sig.
AMTL (n) By Age Group	Between Groups	Combined	539.541	3	179.847	9.475	.000
	Within Groups		2619.537	138	18.982		
	Total		3159.077	141			

Table 3.15. Measures of Association

	Eta	Eta Squared
AMTL (n) * Age Group	.413	.171

A one-way ANOVA permits comparison between three or more groups, examining data variation both between groups and within groups. The between groups analysis compares each group mean and the amount of variation around the sample mean, while within groups examines individual scores in each group and how these scores vary around that particular group mean. Small significance values (<.05) indicate that there are differences between groups, but do not specify which groups differ (refer to Table 3.14).

In order to determine which groups vary and if the differences are significant, post hoc tests conduct pairwise comparisons of all group means. Results from Tukey HSD, Scheffe and LSD tests determine which groups differ and provide significance levels for each group (Table 3.16 shows results from Tukey HSD and Scheffe). The significance column displays a measure of the probability, at the .05 significance level, that each possible group combination comes from the same parent population (Harry 2007). The lower the significance value (p<.05), the more probable the differences between the groups are significant. In addition, these tests provide 95% confidence intervals for each pair wise comparison. If the interval range does not include zero, this confirms that a differences exists between the two groups. As seen in Table 3.16, the greatest group variation is related to age.

Table 3.16. Post Hoc Tests: Multiple Comparisons

	(I) Age Group	(J) Age Group	Mean Difference (I-J)	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Tukey	15-24 Young Adults	25-34 Adults	-.714	.951	-4.21	2.78
		35-44 Mature Adults	-2.917	.112	-6.27	.43
		45-55 Post-Reproduc	-5.273(*)	.000	-8.66	-1.89
	25-34 Adults	15-24 Young Adults	.714	.951	-2.78	4.21
		35-44 Mature Adults	-2.202	.109	-4.72	.32
		45-55 Post-Reproduc	-4.558(*)	.000	-7.12	-1.99
	35-44 Mature Adults	15-24 Young Adults	2.917	.112	-.43	6.27
		25-34 Adults	2.202	.109	-.32	4.72
		45-55 Post-Reproduc	-2.356	.051	-4.72	.01
	45-55 Post-Repro	15-24 Young Adults	5.273(*)	.000	1.89	8.66
		25-34 Adults	4.558(*)	.000	1.99	7.12
		35-44 Mature Adults	2.356	.051	-.01	4.72
Scheffe	15-24 Young Adults	25-34 Adults	-.714	.963	-4.52	3.09
		35-44 Mature Adults	-2.917	.168	-6.56	.73
		45-55 Post-Reproduc	-5.273(*)	.001	-8.96	-1.59
	25-34 Adults	15-24 Young Adults	.714	.963	-3.09	4.52
		35-44 Mature Adults	-2.202	.165	-4.94	.54
		45-55 Post-Reproduc	-4.558(*)	.000	-7.35	-1.77
	35-44 Mature Adults	15-24 Young Adults	2.917	.168	-.73	6.56
		25-34 Adults	2.202	.165	-.54	4.94
		45-55 Post-Reproduc	-2.356	.087	-4.93	.22
	45-55 Post-Repro	15-24 Young Adults	5.273(*)	.001	1.59	8.96
		25-34 Adults	4.558(*)	.000	1.77	7.35
		35-44 Mature Adults	2.356	.087	-.22	4.93

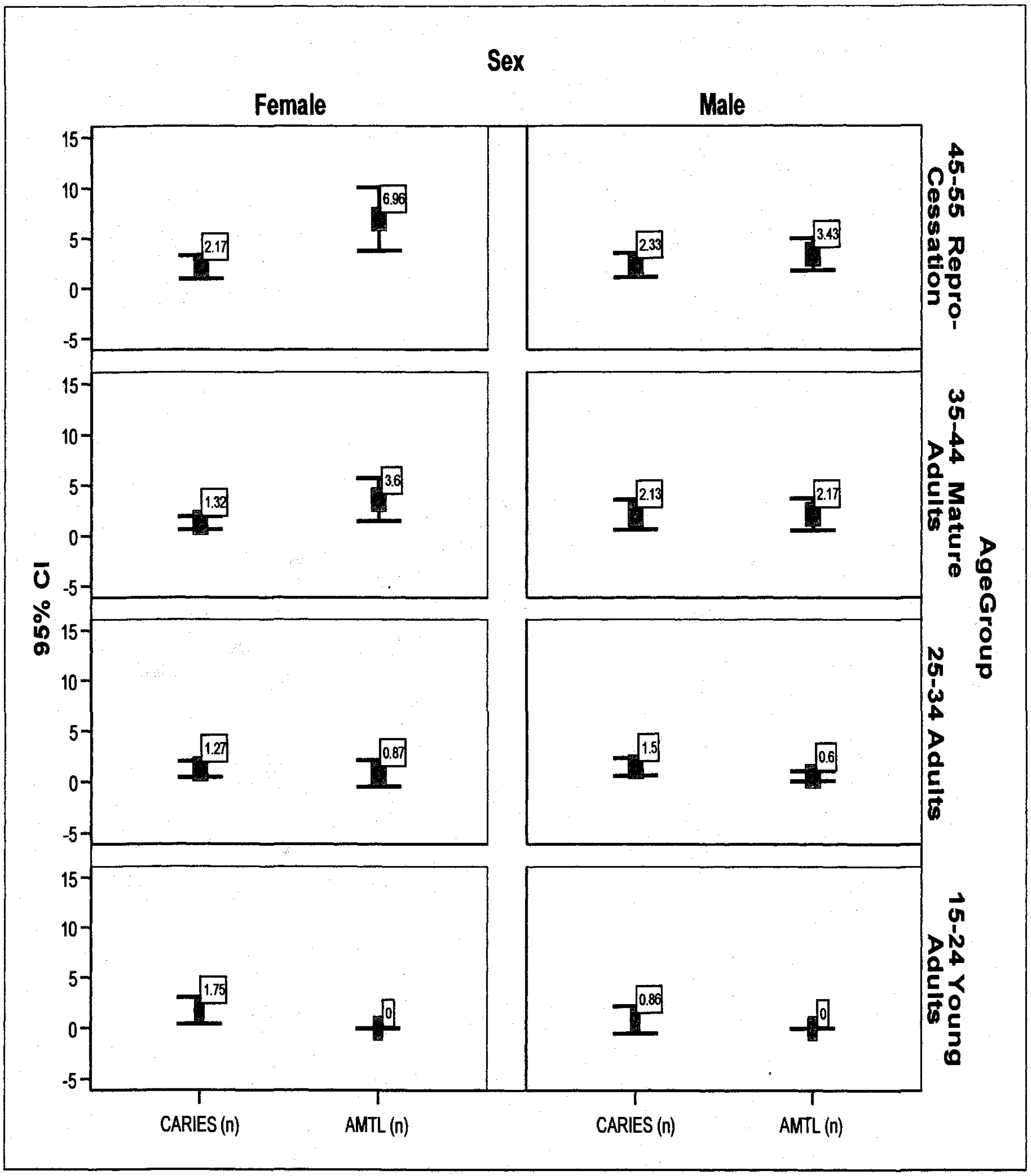
An error bar graph (Figure 3.4) displays pathology data organized by sex and age category. The value labels on the bars indicate the mean of caries and AMTL for each group. This graph presents a visual display of dental health changes over the reproductive lives of Early Agricultural occupants at La Playa. From ages 25-34, males show a slightly greater degree of caries, but females have slightly more tooth loss. During ages 35-44, men exhibit greater caries rates and the women continue a trend of escalating tooth loss. By ages 45-55, men and women exhibit equal caries rates, while La Playa women had experienced substantially greater tooth loss than their male counterparts.

Caries Location by Sex

Another factor to consider with dental pathology and the potential physiological effects of sex is the initiation site of caries. According to Hillson (1996), carious lesions develop differently based on their location on the tooth surface. On a molar, complex crown morphology allow processed carbohydrates to adhere to fissures and grooves on the occlusal surface, providing an environment conducive to cariogenesis. Along the cemento-enamel junction (CEJ) and root surface, Hillson (1996) explains that caries formation is usually associated with periodontal disease and the horizontal loss of alveolar bone (see Figures 3., 3.6 and 3.7).

Periodontitis is an inflammatory disease of the gingivae that can result in "progressive resorption of alveolar bone" (Hillson 1996: 262). As periodontitis advances, the CEJ and root surfaces become exposed, leaving them vulnerable to the formation of carious lesions (Hillson 1996).

Figure 3.4 Data for Caries and AMTL by Sex and Age Category



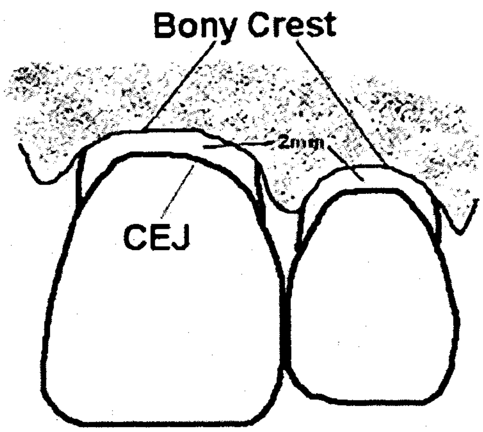


Figure 3.5. Cemento-enamel junction (CEJ) in relation to alveolar bone.

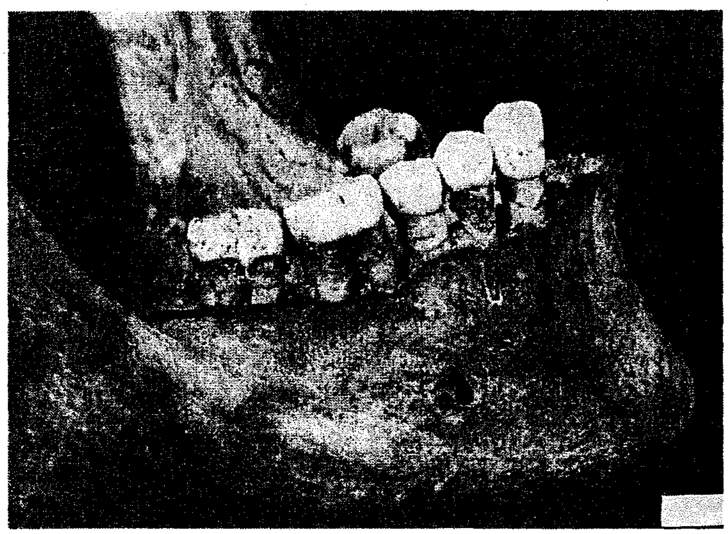


Figure 3.6. Horizontal bone loss from chronic periodontitis (Hillson 1996).

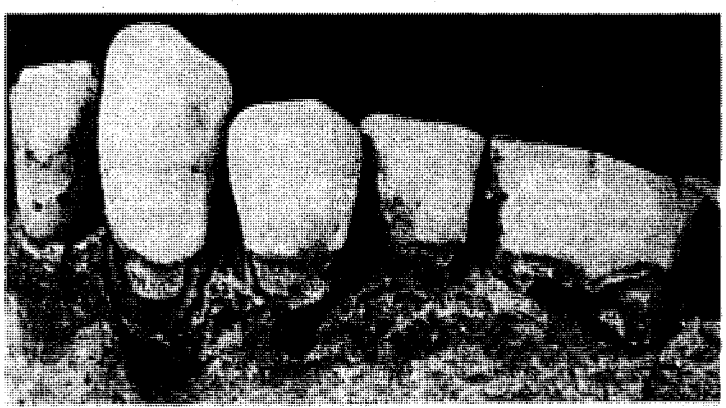


Figure 3.7. Root caries just below the CEJ (Hillson 1996).

In an examination of caries location for the La Playa sample, frequency counts by sex were conducted. A summary of the data is presented in Table 3.17. Occlusal caries (dental code 1) for females totaled 48, while males exhibited 74 occlusal surface caries. Women had 42 root or CEJ caries (dental codes 4 and 5), while men had a total of 28 root or CEJ caries. For sample males, frequency rates of occlusal caries comprised 55% of the total carious teeth observed (*n*=134), compared to the females at 41% of total carious teeth observed (*n*=116). Frequency rates for root or CEJ caries for males was 21%, while females had a 36% rate. The rates recorded for the sample were similar to those recorded by Watson (2005) for the La Playa population (Figure 3.8). The women in the sample exhibit comparable occurrence of both occlusal and root/CEJ caries. These results suggest that periodontal disease may have affected the location of caries formation in females (Figure 3.9).

Table 3.17. Cross tabulation of Caries Location by Sex

			Sex		Total
			Female	Male	
Location	Occlusal	Count	48	74	122
		Expected Count	57.2	64.8	122.0
	Root and CEJ	Count	42	28	70
		Expected Count	32.8	37.2	70.0
Total		Count	90	102	192
		Expected Count	90.0	102.0	192.0

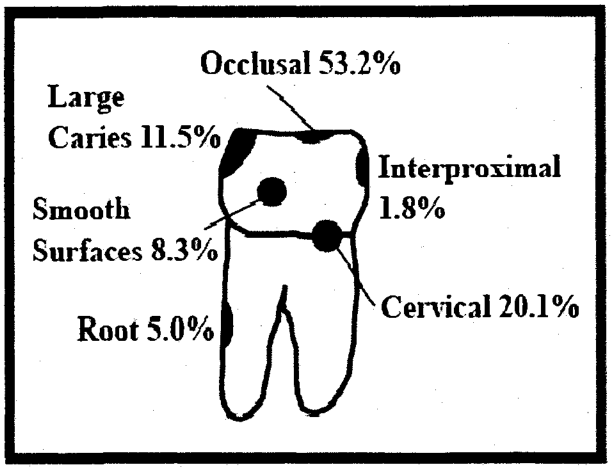
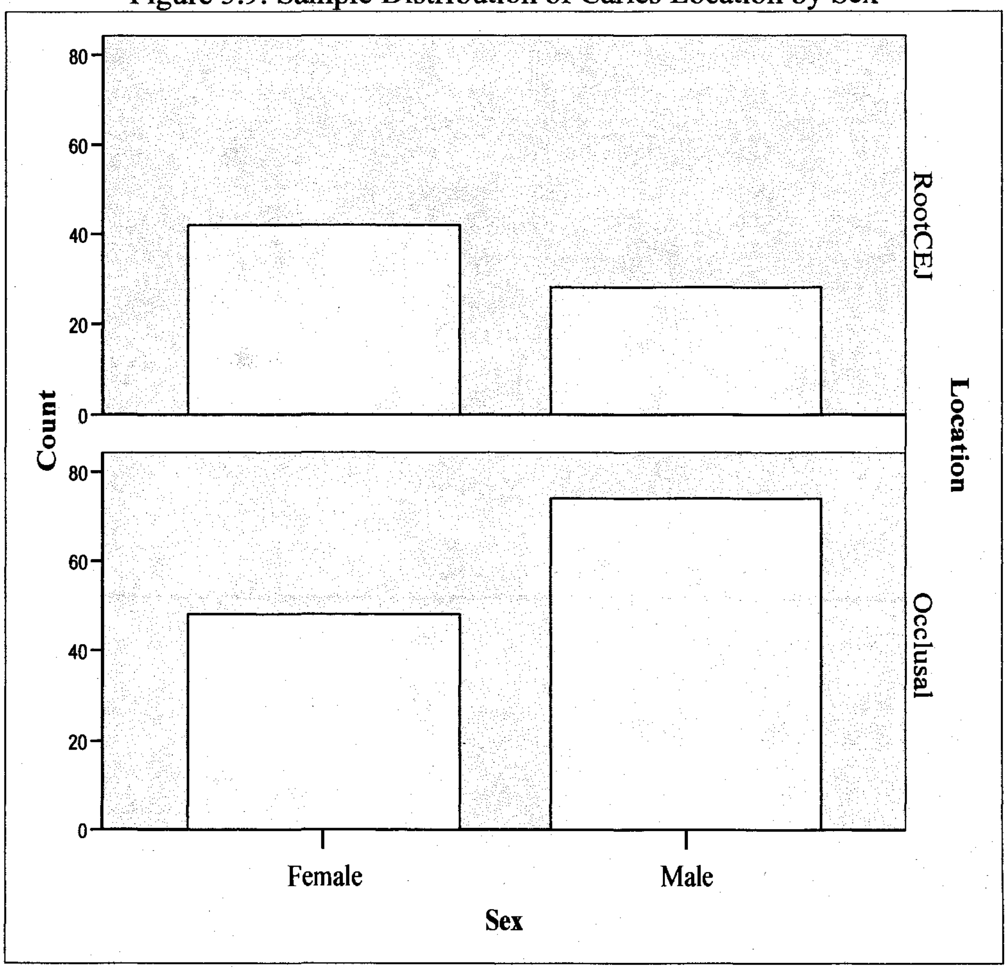


Figure 3.8. Caries distribution of La Playa population. Large caries refer to multi-surface caries where the site of origin is indeterminate (Watson 2005).

Figure 3.9. Sample Distribution of Caries Location by Sex



To evaluate whether caries location varies significantly by sex, a Chi-Square Test for Independence was conducted (Table 3.18). The results indicate that the difference in caries location between males and females is statistically significant, even at the .01 significance level, suggesting there is less than a 1% chance that there are no differences between groups (x^2 =7.62, alpha level = .01, d.f. = 1, x^2 critical = 6.635).

Table 3.18. Chi-Square Results for Caries Location

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	7.621(b)	1	.006		
Continuity Correction(a)	6.814	1	.009		
Likelihood Ratio	7.652	1	.006		
Fisher's Exact Test				.007	.004
Linear-by-Linear Association	7.581	1	.006		
N of Valid Cases	192				

a) Computed only for a 2x2 table
b) 0 cells (.0%) have expected count less than 5. The minimum expected count is 32.81.

While a chi-square test determines if a relationship exists, measures of association test the strength of the relationship between variables. Results from phi and Cramer's *V* effect tests (Table 3.19) confirm that the relationship is significant, although results indicate a weak correlation (significance value = .006, phi = .20, *V*=.20).

Table 3.19. Measures of Association Effect Tests

		Value	Approx. Sig.
Nominal by Nominal	Phi	-.20	.006
	Cramer's V	.20	.006
N of Valid Cases		192	

Socioeconomic Factors

In order to examine socioeconomic factors that might have affected the health of adults at La Playa, there was a search for patterns between variables (i.e., sex, dental pathology, and grave goods). Due to site erosion at La Playa, care must be taken with interpreting test results, as grave goods may have been lost from natural processes. In addition, social status at La Playa during the Late Archaic/Early Agricultural period would have been gained by personal achievement. Walker and Hewlett (1990) found evidence for social differences related to resources among foragers, where those with positions of leadership had greater access to quality resources and exhibit better dental health. The sample data show an association between dental pathology and presence or absence of grave goods.

Watson (2005:87) recorded grave goods for the La Playa population ranging from "elaborate shell ornaments to treatment with ochre at the time of interment", with no statistically significant differences found by sex or site loci. Watson, citing research by Montero (2005:86), suggested that the type of grave offering was related to perceived gender roles during life. Male burials were associated with objects that included smoking pipes and projectile points. Female interments were associated with objects from the domestic sphere such as ground stone and bone awls (Watson 2005:86). Overall, no significant difference between males or females as to the quantity and distribution of goods was recorded for the population (Watson 2005).

For this study, frequency counts of burials with or without grave goods were conducted by sex and pathology (Table 3.20). Data for burials where grave goods were unknown or indeterminate were not included in frequency counts. A total of 39 burials contained grave goods, which is 27.5% of all burials in the sample (Table 3.21). These frequencies support Watson's (2005) results, which recorded 22.8% of excavated burials contained grave offerings. Of the sample, males with grave goods comprise 13.4% of the sample, while females with goods total 14% of the sample. Counts were the same for females and males with no goods (*n*=33), both totaling 23% of the sample. These rates indicate no significant difference by sex as to the presence or absence of grave goods. There are also no observable patterns as to site loci or time period.

Table 3.20. Summary of data by Sex, Pathology and Grave Goods

Variables	Burials with Goods (*n*=)	Burials with No Goods (*n*)	# of Carious Teeth with Goods (*n*)	# of Carious Teeth with No Goods (*n*)	# of AMTL with Goods (*n*)	# of AMTL with No Goods (*n*)
Males (*n*=52)	19	33	68	66	57	77
Females (*n*=53)	20	33	40	65	70	190
Total (*n*=105)	39	66	108	131	127	267

Table 3.21. Pathology frequency rates by Grave Goods

	Caries rate with Grave Goods (%)	Caries rate with No Goods (%)	AMTL rate with Grave Goods (%)	AMTL rate with No Grave Goods (%)
Males	63%	50.4%	44.9%	28.8%
Females	37%	49.6%	55.1%	71.2%

There are differences between men and women based on the presence of grave goods and the total number of carious teeth. While women with grave goods had a total of 40 carious teeth, men with grave goods had a total of 68 carious teeth (Table 3.20). Therefore, men with goods had 63% of all carious teeth in this sub-sample (Table 3.21).

In a Chi-square Goodness of Fit test (Table 3.22), individuals with grave goods were tested for differences between caries frequency by sex. Results indicate statistically significant differences in caries frequency between the groups, even at the .01 significance level (x^2 =7.259, alpha level = .01, d.f. = 1, x^2 critical = 6.635). These differences suggest that men buried with grave goods may have had better, and possibly more frequent, access to the type of processed carbohydrates implicated in caries formation. However, these higher rates did not equate to increased tooth loss for the men, which may be an indicator of better general health.

Table 3.22. Chi Square Results: Individuals with Grave Goods and Caries Frequency

	Sex
Chi-Square(a)	7.259
df	1
Asymp. Sig.	.007

a) 0 cells (.0%) have expected frequencies less than 5. The minimum expected cell frequency is 54.0.

Antemortem tooth loss data show well-defined differences between variables (refer to Table 3.20). Women with grave goods lost 70 teeth antemortem, while men with goods lost 57 teeth. Women with no grave goods lost a total of 190 teeth, exhibiting 2.5 times more tooth loss than men with no grave goods (n=77). In a Chi-square Test for Independence (Tables 3.23 and 3.24), female and male AMTL counts were examined for differences based on the presence or absence of grave goods. Even at the .01 level, results indicate statistically significant differences in the amount of tooth loss between groups, although the measure of association was weak (x^2 =9.85, alpha level = .01, d.f. = 1, x^2 critical = 6.635, phi=.16).

Table 3.23. Chi-Square Results on AMTL by Sex and Grave Goods

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	9.870(b)	1	.002		
Continuity Correction(a)	9.168	1	.002		
Likelihood Ratio	9.687	1	.002		
Fisher's Exact Test				.002	.001
Linear-by-Linear Association	9.845	1	.002		
N of Valid Cases	394				

a) Computed only for a 2x2 table
b) 0 cells (.0%) have expected count less than 5. The minimum expected count is 43.19.

Table 3.24. Measures of Association

		Value	Approx. Sig.
Nominal by Nominal	Phi	-.158	.002
	Cramer's V	.158	.002
N of Valid Cases		394	

a) Not assuming the null hypothesis.
b) Using the asymptotic standard error assuming the null hypothesis.

In a comparison of AMTL among women only, a total of 260 teeth were lost from women, either with or without goods. However, those women without grave goods lost 73% of all the teeth lost by women in this sub-sample (refer to Tables 3.20 and 3.21). In a Chi-square Goodness of Fit (Table 3.25), women were tested for differences between AMTL frequency based on presence or absence of grave goods. Results found statistically significant differences, even at the .01 significance level (x^2 =55.39, alpha level = .01, d.f. = 1, x^2 critical = 6.635). These findings suggest that, in addition to physiological factors affecting the dental health of reproductive-age women at La Playa, there may have been social factors that affected access to resources (see Figure 3.10).

Table 3.25. Chi Square Results: AMTL Data for Women

	Goods
Chi-Square(a)	55.385
df	1
Asymp. Sig.	.000

a) 0 cells (.0%) have expected frequencies less than 5. The minimum expected cell frequency is 130.0.

The error bar graphs display the distribution of burial goods by sex and pathology, including burials where grave goods were undetermined. The central markers and error bars represent, with 95% probability, where the population mean and the data range are expected. Grave goods and caries data are presented in Figure 3.10. The error bars show that men with grave goods have higher caries occurrence than women with grave goods. It is interesting to note that the greater caries frequency for men with grave goods did not equate to greater tooth loss for these individuals. The data show that the dental health of women was impacted more negatively than men, which could have been related to better access to quality resources. The data suggest that there may have been social differences between adult men and women at La Playa.

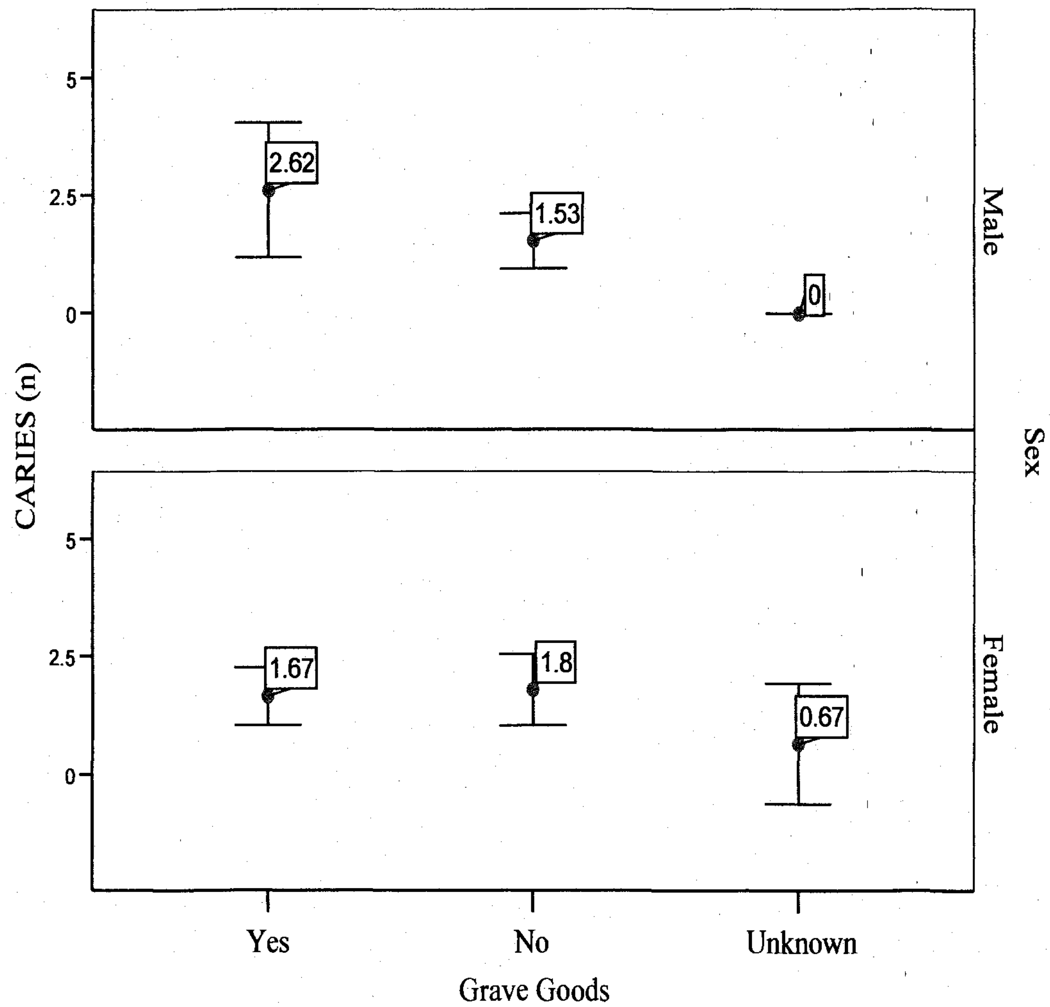


Figure 3.10. The error bar graphs show that males with grave goods had higher caries frequency than females with goods. However, the higher caries rate for men with goods did not equate to greater AMTL. The bar graphs for caries frequency between men and women without goods indicate no significant differences in caries rates.

Figure 3.11 shows AMTL data for men and women based on presence or absence of grave goods. The frequency of AMTL among men with or without grave goods overlaps considerably. The similarity in pathology rates for males indicates that presence or absence of goods is not strongly associated with tooth loss, as it is for the women. The bar graphs demonstrate that women without goods have greater AMTL rates than men without goods.

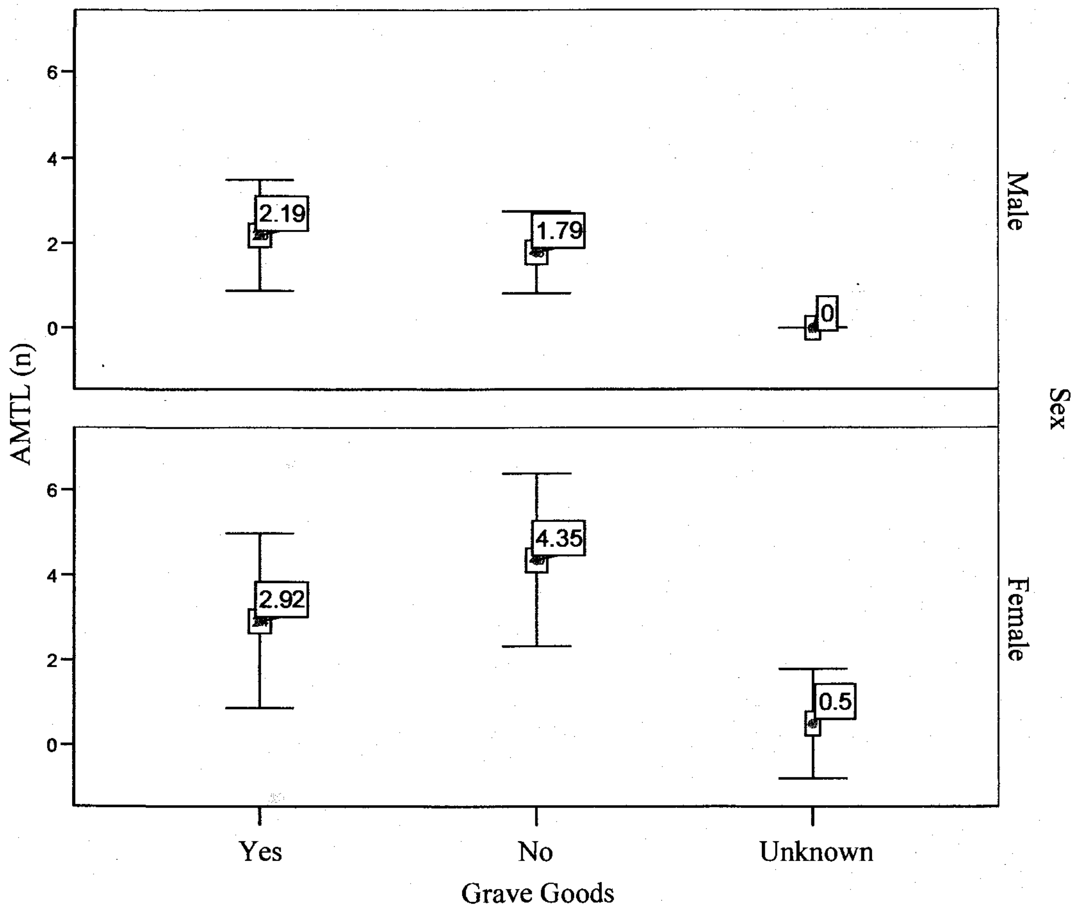


Figure 3.11. The error bar graphs show that AMTL among males was not strongly associated with presence or absence of grave goods. However, for women with no goods, AMTL was significantly greater than for men with no goods.

Figure 3.12 displays error bar graphs of AMTL distribution for women with and without grave goods. Women with no goods exhibit 2.7 times the pathology than women with goods (refer to Table 3.21). The bar graphs show greater dental pathology for women without grave goods, suggesting that there may have been social differentiation among Early Agricultural women at La Playa.

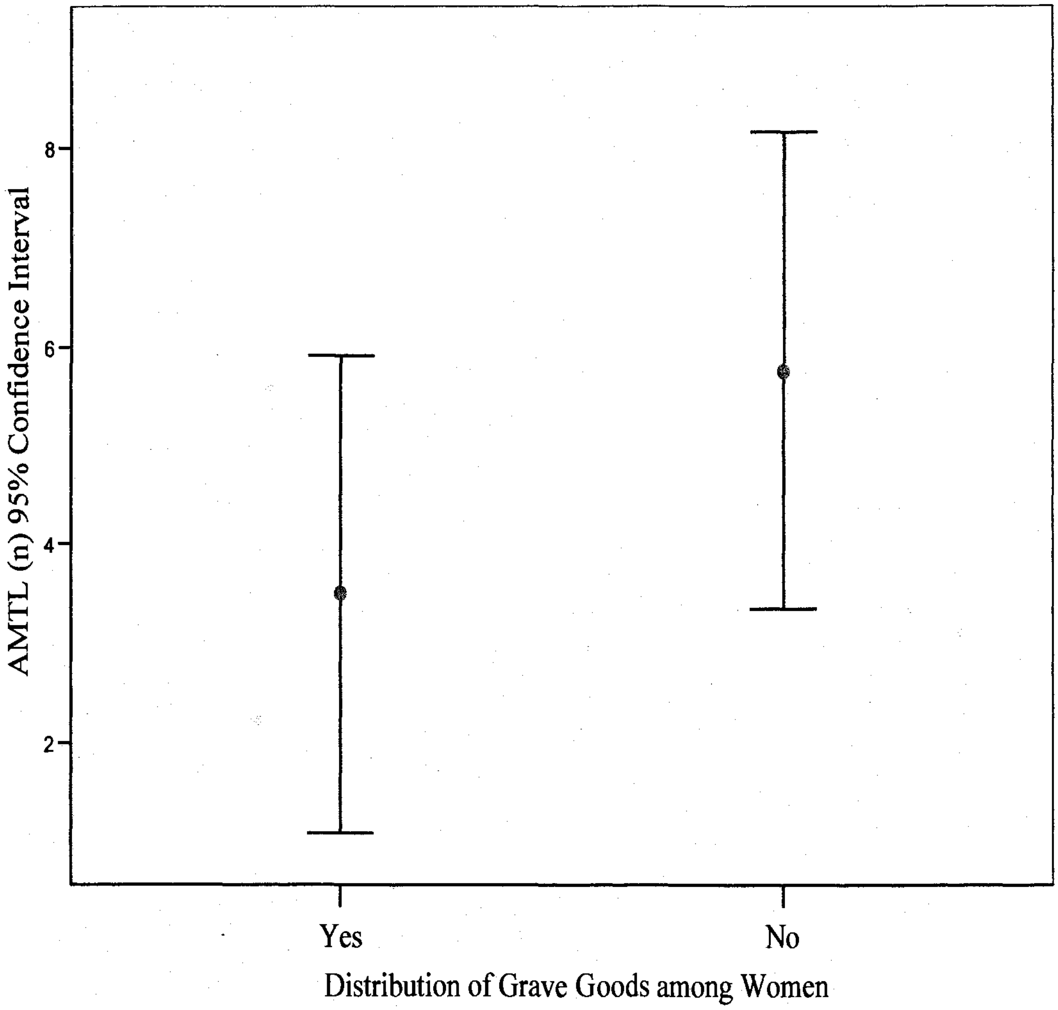


Figure 3.12. The bar graphs indicate that AMTL among females was strongly associated with presence or absence of grave goods. The bars demonstrate that women with no goods had significantly greater AMTL than women with goods.

Summary of Significant Results

The dental data from reproductive-age women and age-matched males who occupied La Playa during the Early Agricultural Period were analyzed for pathology frequency rates and sex-differences in rates across age categories, caries location, and presence or absence of grave goods. Findings are summarized below:

- More than 60% of individuals in the sample were affected by caries. Of these, males had only slightly higher caries rates than females.
- There were actually more women in the sample with caries than men, although the men had more carious teeth per mouth. These findings show that the use of caries frequency rates alone do not accurately describe caries occurrence at La Playa.
- Women had significantly greater tooth loss than men, a portion of which would have been the result of advanced carious decay.
- Caries correction factors were used to adjust caries frequency rates for antemortem tooth loss (AMTL). The corrections did not provide any significant changes to the frequency rates for the sample.
- Older individuals in the sample exhibit greater pathology than younger individuals for both caries and AMTL. The increase in frequency rates is strongly associated with age.
- Women are particularly affected by age-related increases in dental pathology, especially for AMTL. Over their lifespan, women in the sample on average lost twice as many teeth as their male counterparts.

- Men had significantly more occlusal caries than root or cemento-enamel junction (CEJ) caries, while women had equal proportions of caries occur on occlusal, root and CEJ tooth surfaces. These differences in the origination site of caries may be related to hormone-driven oral pathology and periodontal disease.
- Men with grave goods had slightly more caries than women with grave goods. Of note, the greater caries occurrence for men with grave goods did not equate to greater tooth loss for these men.
- Women without grave goods experienced significantly more AMTL than men without goods, indicating that the dental health of women at La Playa was affected by factors that might indicate unequal access to resources.
- In a comparison of AMTL among women, women without grave goods lost 73% of all teeth lost to women in the sample. These differences suggest that there were factors that affected the health of a segment of La Playa women more negatively than others.

CHAPTER FOUR

DISCUSSION AND CONCLUSIONS

Teeth are made from a durable substance (i.e., hydroxyapatite) that is resistant to chemical and physical destruction (White 2000:109). As a result, teeth preserve and are well-represented in archaeological collections in relation to other skeletal material (White 2000). As a biological and physical material, teeth interact both with the internal and external environment of the body, making the study of dentition a valuable source of information about an individual's age, diet, health, and behavior (White 2000:400).

In archaeological populations, dental (and skeletal) remains are one of the major ways that are used to investigate health and nutritional history (Stodder and Martin 1992). Data are examined from numerous perspectives to mitigate what is recognized as the osteological paradox; how much does this individual represent the population as a whole (Goodman 1993). Analysis, therefore, requires a search for patterns within and between populations before offering an interpretation.

This study provides insight into the health consequences of the foraging-to-farming transition, focusing on the higher dental pathology rates for early agricultural females compared to males. The research examined the dental health of an Early Agricultural group from the La Playa site in northern México, with particular emphasis on male-female variation in dental pathology.

The La Playa burial assemblage, from which the sample (*n*=142) for the study is derived, encompasses the entire Early Agricultural Period (B.C. 1600-200 A.D.). The research sample includes females (*n*=71) and males (*n*=71) ranging in age from 15 to 55 years. The age range provides a sample that represents pre-, peak-, and post-reproductive adults at La Playa, and controls for age-related dental pathology and attrition.

Interpretation was approached with caution in using the La Playa collection as a proxy for early agriculturalists. Excavations at the site have been largely guided by erosional processes, as fieldwork is part of collaborative recovery efforts between the *Centro Instituto Nacional de Antropología e Historia* (INAH) in México and archaeologists, students and volunteers from the United States (Watson 2005). As a result, burials have been recovered from eroded contexts, having the potential to skew the sample. However, Watson (2005) suggests that while erosion did play a part in the distribution of burials recovered from site loci, it did not affect the distribution of dental pathologies recorded. This ensures that the La Playa burial sample is random, providing an unbiased sample of early agriculturalists (Watson 2005:189).

The La Playa skeletal collection is the largest in the American Desert West with evenly distributed sex and age ratios, and temporal continuity dating to the San Pedro and Cienega phases of the Early Agricultural period (Watson 2005). In addition, dental arches are relatively well preserved and have been recovered largely intact. Therefore the burial sample is well suited to address research questions into the adoption of agriculture and the effect on human health, providing a more complex look at often overlooked sub-groups.

This study contributed to La Playa's dental database with data collected from forty-seven excavated burials. The use of standardized dental recording codes and charts maintains consistency in data collection (Appendixes B and C). Such continuity ensures that this study, and future research conducted on the collection, can be incorporated into a growing body of literature on early agricultural groups.

A persistent pattern that has been associated with the adoption of agricultural foods includes a decline in general health and an increase in dental pathologies (Larsen 1981, 1995; Steckel et al. 2002; Stodder and Martin 1992). Stodder and Martin (1992) caution that within this basic pattern, a considerable range of variability exists as a result of differences in the pathological process due to environment, demography, and individual susceptibility.

Overall, research has demonstrated that the dental health of early agricultural females was affected more than males (Bridges 1989; Hillson 1996; Larsen 1995, 2000; Lukacs 1996; Steckel et al. 2001, 2002). The traditional explanation for male-female differences is that women tend to "nibble" on carbohydrates more frequently (i.e., "stir-the-pot" syndrome) (Larsen 1987). This explanation, however, assumes a universal female food preference and does not take individual taste into consideration. More importantly, this explanation does not have empirical backing and fails to consider the effects of hormonal fluctuations related to biology on oral health (i.e., pregnancy). Another argument for higher female caries rates is the timing of the eruption of teeth, which averages around 3% earlier for girls compared to boys (Hillson 1996; White 2000:345). The average eruption time, however, varies widely between individuals and populations (Hillson

1996). Earlier eruption timing, however, likely would not account for the degree of greater dental pathology recorded for females.

This study proposes an alternative explanation for the sex-variation in dental pathology, examining biological and cultural contributors to the phenomenon using an interdisciplinary perspective. Results contribute to the literature by considering the role of pregnancy in the lives of women. With the dietary shift to processed carbohydrates and the population growth associated with the subsistence transition, the effect that increased parity and pregnancy-related factors had on the dental health of women warrants examination. Sellen and Mace (1997) found that the adoption of agriculture was associated with increased fertility in several ways: a predictable food supply available to reproductive-age women, changing activity levels and the availability of appropriate weaning foods (i.e., cereal grains) thereby reducing lactational duration.

Dental caries is a disease process with several prerequisites (Hillson 1996; White 2000). In the oral environment, fermentable carbohydrates pass through and adhere to tooth fissures and grooves. Dental plaque, which Hillson (1996:254) describes as "a dense accumulation of microorganisms on the tooth surface", is colonized by bacteria (e.g., *Streptococcus mutans*) that metabolize starches and sugars in carbohydrates. As the bacteria metabolize, they produce acids and vulnerable tooth surfaces break down, resulting in cavity formation (Hillson 1996). Carious lesions can form on any tooth surface where plaque accumulates, but often begin in the fissures and grooves that are found on the occlusal surface (White 2000).

Substantial changes occur in dental tissues during pregnancy as circulating hormone levels intensify the response of gum tissue to irritants (i.e., bacteria) present in dental plaque (Lieff et al. 2004). Thus, the physiological changes associated with pregnancy, when combined with a cariogenic diet, are known to impact maternal dental health through an environment favorable to caries formation and dental decay (AAP 2006; Burakoff 2003; Halpern 2008). In addition, women of peak-reproductive years experience greater nutritional and physiological stressors compared to age-matched men (Sellen and Mace 1997).

Analyses resulted in significant observations that are used in a meaningful discussion of the dental health of reproductive-age women. The effects of advanced carious decay and tooth loss on general health and well-being are of relevance for women and their families today. Interpretation contributes to a more dynamic picture of human biological and cultural adaptation during the Early Agricultural period. Results from the study identified a pattern for La Playa's reproductive-age women that indicates the women experienced greater dental disease with significantly more tooth loss compared to age-matched men ($p<.0005$). Results show that among La Playa adults, females had substantially more tooth loss than their male counterparts, with women losing an average of 3.7 teeth per mouth compared to men who lost on average 1.89 teeth. These findings identify a pattern suggesting that changes associated with foraging-to-farming subsistence behaviors impacted women's dental health more negatively than men.

Understanding the foraging-to-farming transition during the Early Agricultural period in the Sonoran Desert provides insight into life at La Playa during this period. Fish and Fish (1994) describe a wide range of varying mobility strategies and agricultural reliance among early Southwest agriculturalists. The researchers (1994:102) explain that more than just enduring in a marginal environment, "desert farmers of the Southwest" would have devised cultural means to challenge the "difficult southwestern environment". Wills (1988:148) offers that the decision to adopt cultigens required not only the socioeconomic system to accommodate such a change, but also the "desire to enhance the predictability of some aspects of the economy". In light of this reasoning, the adoption of agriculture could be interpreted as a choice for "predictability" in the face of "increasing… uncertainty" that may have been predicated on "density-dependent socioeconomic transformations" (Wills 1988:143-155).

Roth and Freeman (2008) found evidence for subsistence adaptations during the Middle Archaic period (3500-1500 BC) preceding the Late Archaic/Early Agricultural. The authors suggest that foraging groups had a suite of behaviors in place that allowed for the smooth transition of maize into their diets. Such behaviors include the seasonal use of alluvial floodplains (e.g., La Playa) during summer months, the exploitation of seed plants on floodplains and the technology for processing cultigens (Roth & Freeman 2008). Adams (1999:492) suggests that when food-processing techniques are part of the cultural milieu, cultigens such as maize are readily assimilated into the existing subsistence strategy.

Therefore, the transition to agriculture in the Sonoran Desert can be understood as mixed-economy subsistence with supplemental cultigen use until conditions (i.e., population growth or environmental stress) led to greater agricultural dependence. The archaeological evidence supports this view, indicating that San Pedro groups had the technology to intensify reliance on cultigens, even as wild plant resources continued to be part of their subsistence pattern (Diehl 2005; Roth & Wellman 2001).

Watson (2008) states that during the San Pedro phase at La Playa, the inhabitants practiced a mixed-economy exploiting local cactus, mesquite beans, agave and domesticated cultigens, such as maize. He suggests that the indigenous plants of the Sonoran provided foods that are high in sugar and sticky carbohydrates. In effect, the consumption of wild cariogenic resources at La Playa would have obscured increased reliance on agricultural foods (Watson 2008).

In sum, the scenario posited by this study is supported by the archaeological evidence. The diet at La Playa included cariogenic carbohydrates throughout the Early Agricultural period. Substantial quantities of ground stone offer evidence for intensified food processing strategies, likely to feed the growing population. Increased sedentism is seen with greater local investment in the production of shell goods. Thus, the socioeconomic conditions that resulted in changes to population density and, subsequently dental health, were in place during the Early Agricultural occupation at La Playa.

Discussion of Results

Research into caries frequencies based on subsistence has shown that Paleolithic hunting and gathering groups experienced minimal dental caries, with rates averaging 2% (Scott & Turner 1988). During the Holocene, intensification of food production resulted in the increased consumption of sticky carbohydrates known to "exacerbate caries formation" (Scott & Turner 1988:115). As a result, agriculturalists have high caries rates, often exceeding 10% (Scott & Turner 1988).

The observed caries rate for the study sample (11.2%) falls within the range that would be expected for agriculturalists and confirms the population caries frequency (11.5%) recorded by Watson (2005:143). These findings indicate that, although mixed-economy subsistence usually results in lower caries rates (averaging 5%), at La Playa, the use of local cariogenic foods combined with maize consumption resulted in caries rates resembling those of agricultural populations (Watson 2008).

Adult males in the sample were found to have a slightly higher caries rate (12.1%), although insignificantly (p=.522), than adult females (10.3%). This corresponds with Watson's (2005) findings that showed La Playa males with higher caries rates than females (6.9% versus 4.5%, respectively). However, the individual caries rates indicate that there were more women in the sample with caries (63.4%) than men (57.7%). This figure shows that, although adult males had more carious teeth per mouth than adult females (males 1.89 versus females 1.64), the number of individual women with carious lesions was greater. This finding suggests that much of the tooth loss among reproductive-age women at La Playa may have been due to advanced carious decay.

When examined by age group, at the end of the reproductive life-cycle, women had comparable caries occurrence to age-matched men. In the 45-55 year old age group, men had a mean of 2.33 caries compared to women, with a mean of 2.17 caries. These results support Watson's (2005:192) argument that the lower caries frequency seen for La Playa females was influenced by the greater degree of AMTL they exhibited. A more accurate picture of sex-specific variation among adult La Playans emerges when combining caries and AMTL rates. The combined pathology rate for women is 33.6% compared to 24.4% for men.

Watson (2005:154) notes that, for the La Playa population, females had twice the amount of AMTL than males (females had 16.4% versus males with 8.4%). This study's analyses of AMTL identified significant male-female differences among reproductive-age adults, with a strong correlation between sex and AMTL (p=.022, d=.39). Moreover, results show that the proportion of teeth lost by the women is significantly greater than the amount that would be expected, given equal chances of tooth loss for both adult men and women (p<.0005). These findings reveal a profound impact on dental health specific to La Playa's reproductive-age women.

With the sample organized by age group, the pattern of tooth loss among women intensifies over the reproductive years. Women from 45-55 years of age exhibit more than double the AMTL compared to age-matched men, with a mean of 6.96 versus 3.43 respectively. These findings suggest that, on average, a woman living at La Playa during the Early Agricultural period could anticipate losing twice as many teeth as her male counterpart. Therefore, it could be reasonably argued that the accumulative effects of tooth loss would have resulted in a number of health complications specific to women.

General health problems are sequelae to tooth loss, usually from reduced masticatory function (Tu & Gilthorpe 2005). With nutritional needs compromised, an individual frequently experiences lowered immunity. It is likely, then, that La Playa women faced additional health issues resulting from decreased nutritional intake due to tooth loss. Clinical research has shown that individuals with a substantial degree of tooth loss are at greater risk for a number of health related issues, including higher mortality rates (Abnet et al. 2005; Bobetsis et al. 2006; Boggess 2006; Halpern 2008; Tu & Gilthorpe 2005). While causal mechanisms are not yet fully understood, an association between systemic infection due to invasive oral bacteria is implicated. The process of dental decay and compromised immunity may have led to a cycle of deteriorating health for reproductive-age La Playa women.

To adjust for the degree of AMTL recorded for La Playa women, the study re-examines Lukacs' (1995) "caries correction formula and the "proportion correction factor" proposed by Erdal and Duyar (2003). However, these formulas failed to provide statistically significant changes for the sample or by sex. The results may have been affected by data collection recording codes, which did not permit the collection of data into a separate category for carious pulp exposure.

In addition to the conditions necessary for cariogenesis (i.e., susceptible tooth surface, fermentable carbohydrates and bacteria), there are environmental factors known to influence dental health. For example, diets that are high in grit can result in reduced caries formation as the mastication of abrasive particles effectively "cleans" the teeth and wears down enamel surfaces, thereby preventing or removing carious lesions (Hillson 1996). Watson (2005) found evidence for a moderate amount of dietary grit at La Playa, which may have affected caries formation for the population.

An additional modifying factor may have been the amount of fluoride present in the local environment. Elevated fluoride levels in the soil or water supply could have had a modifying effect on caries formation, although fluoride levels likely fluctuated over time. Test results reported by Watson (2005:96) on La Playa skeletal samples indicate that the level of fluoride present in the samples was relatively high. Environmental factors such as dietary grit or fluoride would have potentially affected all La Playa inhabitants and, therefore, would not be expected to significantly affect results for this study.

There was a pattern of tooth loss identified in relation to the presence or absence of burial goods (refer to Tables 3.20 and 3.21). Women who were buried with out grave goods exhibited the most tooth loss for the sample (71%). Results show that the women without goods had significantly greater tooth loss, losing 2.5 times more teeth than men without goods (alpha level=.01, p=.002). Perhaps even more important was the finding that among women only in the sample, women without burial goods had significantly more tooth loss, at the .01 level, than women buried with goods (p <.0005).

In her data collection from La Playa skeletal remains, Ethne Barnes (cited in Watson 2005:89-90) observed that those individuals who received burial offerings showed less effects from functional stress (DJD) than those buried without goods. Watson (2005:208) suggested that due to increased pressure to feed a growing population at La Playa, there may have been some limited social differentiation. It is plausible that the skeletal and dental health differences found in association with grave goods could have been the result of social factors primarily affecting only a portion of La Playa women. While evidence for inequalities relating to the control of resources in prehistoric societies may not be readily apparent, expanding social spheres associated with agricultural intensification and craft specialization (i.e., manufacture of shell bracelets) may have been emerging at La Playa.

Moreover, the women who exhibited the poorest dental health would likely have been the most vulnerable to the secondary effects of dental disease and tooth loss (e.g., decreased nutrition and systemic infection). These health affects would have had implications for their children as well (Bobetsis et al. 2006).

Black Mesa Comparative Study

A comparative study of a dental sample (*n*=25) from a fully agricultural group in Black Mesa, Arizona identified sex-specific variation in caries occurrence for reproductive-age individuals (Fields 2006). Previous research on the Black Mesa skeletal sample by Martin and colleagues (1991) indicates that females, dating to the early (AD 800-1050) and late (AD 1050–1150) Pueblo periods, had higher caries rates compared to males. In addition, the researchers found that Black Mesa females were dying younger than Black Mesa males, a phenomenon the researchers attributed to reproductive-related stress.

Findings from the Black Mesa sample of adults, ranging in age from 15 to 40, suggest that a combination of dietary and sex-specific factors resulted in higher female caries occurrence (Fields 2006). Chi-square analysis of caries data from Black Mesa identified a statistically significant association between caries and sex (p=.019). Black Mesa reproductive-age women (*n*=17) had a caries rate of 16.26% compared to age-matched men (*n*=8), with 6.86% caries rate. Comparison of AMTL by sex failed to identify any statistically significant differences, although Black Mesa adult women experienced more tooth loss than adult men (7.93% versus 1.96% respectively).

The small sample sizes may have affected results for the Black Mesa sample. In addition, the diet at Black Mesa centered on processed maize, while La Playa inhabitants relied on a mixed economy. Although adult males at La Playa had a slightly higher caries rate than adult females (12.1% for males versus 10.3% for females), it is likely that caries rates for La Playa women were affected by the significant tooth loss recorded. While Black Mesa sample sizes were problematic, the study found that there were sex-differences in dental pathology rates. Results indicate that reproductive-age women at Black Mesa were impacted by cultural (i.e., sedentism) and biological (i.e., pregnancy-related hormonal fluctuations) dynamics more than their male counterparts.

Implications for Agricultural Women Today

This study has potentially far-reaching implications for women in marginal farming communities, as results provide understanding into the development of long-term health trends formed during the childbearing years. Research into human health and complexity helps to identify factors that might place mothers and infants at-risk.

Clinical studies have shown that maternal oral health affects not only the mother, but can impact the health of her infant in critical ways (Bobetsis et al. 2006; Boggess & Edelstein 2006; Burakoff 2003; Laine 2002; Lieff et al 2004; Silk et al. 2008). Boggess and Edelstein (2006) found transmission of *Streptococcal* bacteria from mother to child via saliva, thus predisposing children to dental decay and infectious disease.

Archaeological research (Larsen 1987:367) has shown that interpreting the health of the mother is critical to understanding the risk and survival of the infant. For example, in their research of Black Mesa agriculturalists, Nelson and colleagues (1994) found evidence for a high degree of infection among infants, suggesting the possibility of acquired infection from mother to child.

Findings from this study suggest that among the women at La Playa, there may have been factors related to unequal access that affected the dental health of a portion of the sample women. Those women buried without grave goods exhibited signs of compromised dental health, losing 190 teeth compared to women buried with goods, who lost a total of 70 teeth. These findings are of significance for women living in marginal communities today, where access to dental and prenatal care may be limited. Underprivileged women and their infants are particularly vulnerable to negative health outcomes, as seen with the high rates of maternal and infant mortality in many economically deprived communities (WHO 2008).

Greater understanding of the complex role of hormone-driven oral pathology as it relates to systemic infection and contagion would be useful in programs aimed at prevention (Silk et al. 2008). Education that includes oral health information targeting at-risk women might assist in early intervention. It is hoped that results from this study will contribute to efforts to improve the lives of women by providing understanding of the development of health trends over time.

Recommendations

The scope of this thesis was restricted to examining biological and cultural factors (i.e., diet, mobility, population growth, and dental caries) in relation to AMTL. The sample used represents the reproductive years to prevents data distortion from age-related tooth loss, but excludes evidence of post-menopausal dental complications. Current dental research suggests that alveolar bone loss may escalate in post-menopausal women, as with the loss of bone density from osteoporosis (Halpern 2008; Jeffcoat et al. 2000).

According to Koritzer (1968), the cause of tooth loss in archaeological populations should be evaluated based on additional causes of tooth loss during life, which can include periodontal disease. Hillson (1996) explains that periodontal disease is a pathological process that weakens the tissues that support dentition often resulting in tooth loss. In addition, chronic periodontal disease over time results in receding tissues that leave the cemento-enamel junction (CEJ) and root surfaces vulnerable to caries formation (Hillson 1996). The etiology can be further complicated by the host's immune response, which adds to inflammation and tissue degeneration (Hillson 1996). Periodontal disease has been correlated with the increased presence of dental plaque and bacteria, contributing to problems that arise with the spread of bacteria beyond the mouth (Halpern 2008; Jeffcoat et al. 2000; Silk et al. 2008).

The diagnosis of periodontal disease in archaeological populations requires an examination of the alveolar bone for signs of horizontal bone loss (Hillson 1996). In addition, the origination site of caries can be used as an indicator of periodontal health. Watson (2005:189) identified periodontal disease as among the most prevalent dental pathologies observed for the La Playa population, with a rate of 24.1%. An analysis of the caries origin site for the La Playa sample indicates that the location of caries varied significantly by sex (p=.006). Adult women had 48 occlusal caries and 42 root/CEJ caries, while adult men had 74 occlusal caries and 28 root/CEJ caries.

These sex-based differences may be associated with the effects of hormonal fluctuations on the periodontal health of women. Further research of sex-variation in the occurrence of periodontal disease in archaeological populations could provide insight into issues that concern post-menopausal women today.

Conclusion

Archaeological evidence from region to region indicates that the adoption of agriculture did not occur uniformly with the advent of the Holocene (Larsen 1995). In the Sonoran Desert, research into the foraging-to-farming transition has shown that groups adapted culturally as they interacted with their environments (Diehl 2005; Roth 1996; Wills 1988). By placing data in local contexts, dental health provides a measure of the impact that subsistence change had on human populations and sub-groups.

This study contributes to a more dynamic picture of human health and history by considering the biological changes that are associated with various life-stages (Goodman 1993). In addition, research into the biological basis for sex-differences in health indicators promotes an understanding of the role of sex in human lives. Findings from this study provide insights into the development of health trends through time, with special significance for females of childbearing age. Results indicate that the adoption of an agricultural lifestyle brought profound and enduring consequences to the lives of women.

APPENDIX A

THESIS RESEARCH SAMPLE DATA

Burial	Sex	Age Group	Approx Age	Goods	Area	Time	Teeth	AMTL	Caries
5	Female	15-24 Young Adults	23	Yes	EC	Unknown	27	0	1
12	Female	45-55 Repro-Cessation	50	Yes	LE	Late Cienega	32	0	1
30	Female	45-55 Repro-Cessation	45	No	LM	Unknown	13	11	0
35.2	Female	35-44 Mature Adults	40	No	LE	Unknown	15	7	1
48	Female	45-55 Repro-Cessation	50	No	LE	Unknown	3	7	2
51	Female	35-44 Mature Adults	40	No	LE	Unknown	15	6	4
52	Female	45-55 Repro-Cessation	50	No	LE	San Pedro	2	12	0
60	Female	35-44 Mature Adults	35	No	LE	Unknown	11	0	0
61	Female	45-55 Repro-Cessation	50	No	LE	Unknown	2	30	0
72	Female	45-55 Repro-Cessation	55	No	LE	Unknown	0	16	0
77	Female	45-55 Repro-Cessation	50	No	LE	Unknown	23	7	6
97.2	Female	25-34 Adults	30	No	LE	Unknown	5	0	1
100	Female	35-44 Mature Adults	40	No	LE	Unknown	12	3	1
101	Female	45-55 Repro-Cessation	50	No	LE	Unknown	4	2	0
105	Female	35-44 Mature Adults	40	No	LE	Unknown	17	2	2
111	Female	25-34 Adults	30	Yes	HA	Late Cienega	27	0	0
119	Female	45-55 Repro-Cessation	45	No	LE	Unknown	30	0	0
126	Female	15-24 Young Adults	24	No	LE	Unknown	32	0	5
127	Female	35-44 Mature Adults	35	No	LE	Unknown	22	1	4
128	Female	15-24 Young Adults	20	Yes	LE	Unknown	6	0	1
129	Female	35-44 Mature Adults	40	No	LE	Unknown	2	0	0
133	Female	35-44 Mature Adults	40	No	LE	Unknown	9	8	0
160	Female	35-44 Mature Adults	35	No	LE	Unknown	6	0	0
162	Female	35-44 Mature Adults	40	No	LE	Unknown	7	0	0
168	Female	35-44 Mature Adults	40	No	LE	Unknown	14	0	1
174	Female	45-55 Repro-Cessation	50	No	HA	Unknown	8	20	1
181	Female	35-44 Mature Adults	40	No	LE	Unknown	9	0	2
184	Female	25-34 Adults	30	Yes	LE	Unknown	31	0	2
188	Female	45-55 Repro-Cessation	45	Yes	LE	Unknown	5	0	0
189	Female	35-44 Mature Adults	40	No	LE	Unknown	10	13	0
208	Female	45-55 Repro-Cessation	50	No	LE	Unknown	21	10	6
245	Female	45-55 Repro-Cessation	45	No	EC	Unknown	20	3	4
258	Female	25-34 Adults	30	No	LE	Unknown	8	0	1
264	Female	35-44 Mature Adults	40	No	LE	Unknown	15	8	0
291	Female	45-55 Repro-Cessation	50	Yes	HA	Early Cienega	24	6	3
299.1	Female	35-44 Mature Adults	40	No	HA	Unknown	1	5	1
301	Female	25-34 Adults	30	No	HA	Unknown	30	0	0
308	Female	35-44 Mature Adults	40	No	HA	Unknown	6	8	0

Burial	Sex	Age Group	Approx Age	Goods	Area	Time	Teeth	AMTL	Caries
310	Female	25-34 Adults	30	No	HA	Unknown	12	0	4
313	Female	35-44 Mature Adults	40	No	HA	Late Cienega	22	0	4
316	Female	15-24 Young Adults	24	No	HA	Unknown	31	0	2
318	Female	35-44 Mature Adults	40	No	HA	Unknown	2	0	0
319	Female	45-55 Repro-Cessation	45	No	LM	Unknown	18	7	1
320	Female	45-55 Repro-Cessation	45	Yes	LM	Unknown	25	1	1
323	Female	25-34 Adults	30	No	LM	San Pedro	9	0	0
326	Female	45-55 Repro-Cessation	45	No	LM	Unknown	20	2	10
352	Female	15-24 Young Adults	20	No	LM	Unknown	25	0	1
357.3	Female	25-34 Adults	30	No	LM	Unknown	20	0	2
366	Female	35-44 Mature Adults	40	Yes	LE	Late Cienega	29	2	2
369.1	Female	45-55 Repro-Cessation	45	No	EC	Unknown	19	2	6
411	Female	25-34 Adults	30	Yes	EC	Unknown	31	0	1
414	Female	15-24 Young Adults	20	Yes	EC	San Pedro	32	0	1
421	Female	45-55 Repro-Cessation	50	Yes	LE	Unknown	25	7	3
430	Female	35-44 Mature Adults	40	Yes	LE	Late Cienega	32	0	2
433	Female	35-44 Mature Adults	40	Yes	LE	Unknown	17	1	5
460	Female	25-34 Adults	30	Unknown	HA	Unknown	1	0	0
471	Female	45-55 Repro-Cessation	45	Yes	EC	Unknown	16	9	4
473	Female	35-44 Mature Adults	35	Yes	LE	Unknown	11	21	1
474	Female	45-55 Repro-Cessation	50	Unknown	LE	Unknown	27	3	1
479	Female	15-24 Young Adults	16	Unknown	EC	Unknown	28	0	0
484	Female	15-24 Young Adults	16	Unknown	LE	Unknown	31	0	3
489	Female	35-44 Mature Adults	35	Yes	LE	Unknown	8	0	0
490	Female	45-55 Repro-Cessation	45	Unknown	LE	Unknown	7	0	0
493	Female	35-44 Mature Adults	35	Unknown	OTHER	Unknown	7	0	0
496	Female	25-34 Adults	30	Yes	EC	Unknown	1	8	0
500	Female	25-34 Adults	30	Yes	LE	Unknown	28	0	1
505	Female	35-44 Mature Adults	35	Yes	LM	Unknown	18	5	3
506	Female	45-55 Repro-Cessation	50	Yes	LM	Unknown	11	5	1
507	Female	25-34 Adults	25	Yes	LM	Unknown	27	0	4
508	Female	25-34 Adults	30	Yes	LM	Unknown	1	0	0
509	Female	25-34 Adults	25	Yes	LM	Unknown	12	5	3
3	Male	45-55 Repro-Cessation	45	Yes	OTHER	San Pedro	10	0	1
11	Male	45-55 Repro-Cessation	50	Yes	LE	Early Cienega	18	8	1
29	Male	45-55 Repro-Cessation	50	Yes	LM	Unknown	0	10	0
35.1	Male	25-34 Adults	30	No	LE	Unknown	30	0	5
49	Male	45-55 Repro-Cessation	50	No	LE	Unknown	16	7	6
71	Male	35-44 Mature Adults	40	No	LE	Unknown	12	0	0

Burial	Sex	Age Group	Approx Age	Goods	Area	Time	Teeth	AMTL	Caries
93	Male	25-34 Adults	30	Yes	HA	Early Cienega	30	2	5
96	Male	35-44 Mature Adults	40	No	LE	Unknown	5	0	1
97.1	Male	35-44 Mature Adults	40	No	LE	Unknown	6	0	0
97.3	Male	25-34 Adults	30	No	LE	Unknown	1	0	0
98	Male	35-44 Mature Adults	40	Yes	LE	Unknown	2	9	0
99	Male	35-44 Mature Adults	40	No	LE	Unknown	19	3	0
103	Male	35-44 Mature Adults	40	No	LE	Unknown	3	0	1
108	Male	35-44 Mature Adults	40	No	LE	Unknown	1	0	0
109	Male	35-44 Mature Adults	40	Yes	LE	Unknown	4	0	0
113	Male	35-44 Mature Adults	35	No	HA	Early Cienega	18	1	1
118	Male	25-34 Adults	30	Yes	LE	San Pedro	28	0	4
121	Male	35-44 Mature Adults	40	Yes	LE	Unknown	20	0	9
130	Male	45-55 Repro-Cessation	50	No	LE	Unknown	4	2	1
151	Male	35-44 Mature Adults	40	No	LE	Unknown	24	3	0
154	Male	15-24 Young Adults	24	Yes	LE	Unknown	4	0	0
156	Male	25-34 Adults	30	No	LE	Unknown	9	1	1
158	Male	25-34 Adults	30	No	LE	Unknown	22	1	0
167	Male	25-34 Adults	30	No	LE	Unknown	5	0	0
172	Male	15-24 Young Adults	20	No	LE	Unknown	32	0	3
173	Male	45-55 Repro-Cessation	45	No	LE	Unknown	29	0	7
190	Male	45-55 Repro-Cessation	45	No	LE	Unknown	0	10	0
247.1	Male	45-55 Repro-Cessation	45	No	EC	Unknown	30	0	4
259	Male	35-44 Mature Adults	35	No	LE	Unknown	18	1	3
263	Male	35-44 Mature Adults	35	No	LE	Unknown	12	3	3
279	Male	25-34 Adults	25	Yes	LE	Unknown	22	0	0
283	Male	35-44 Mature Adults	35	No	LE	Unknown	5	0	0
292	Male	15-24 Young Adults	24	No	HA	Early Cienega	29	0	3
302	Male	45-55 Repro-Cessation	45	No	HA	Unknown	18	6	1
314	Male	35-44 Mature Adults	40	No	HA	Unknown	4	0	0
315	Male	35-44 Mature Adults	40	No	HA	Unknown	16	16	5
317	Male	25-34 Adults	30	No	OTHER	Unknown	5	0	1
321	Male	35-44 Mature Adults	40	No	LM	Unknown	7	2	1
322	Male	45-55 Repro-Cessation	45	No	LM	Unknown	1	3	0
324	Male	45-55 Repro-Cessation	45	Yes	LM	Early Cienega	29	2	1
325	Male	15-24 Young Adults	18	No	LM	Unknown	2	0	0
345	Male	35-44 Mature Adults	35	No	LM	Unknown	0	3	0
356	Male	25-34 Adults	30	Yes	LM	Unknown	12	0	0
357.4	Male	25-34 Adults	30	No	LM	Unknown	22	1	5
357.8	Male	25-34 Adults	30	No	LM	Unknown	6	0	1

Burial	Sex	Age Group	Approx Age	Goods	Area	Time	Teeth	AMTL	Caries
359	Male	45-55 Repro-Cessation	45	No	LM	Unknown	12	0	2
360	Male	35-44 Mature Adults	40	Yes	LM	Early Cienega	29	0	3
361.1	Male	45-55 Repro-Cessation	45	Yes	LE	Unknown	23	0	1
361.2	Male	45-55 Repro-Cessation	50	No	LE	Unknown	26	0	1
364	Male	25-34 Adults	30	No	LE	San Pedro	32	0	0
367	Male	45-55 Repro-Cessation	40	No	LE	Unknown	20	5	4
370	Male	25-34 Adults	30	No	EC	Unknown	8	0	0
412	Male	35-44 Mature Adults	40	No	EC	Unknown	10	4	1
413	Male	45-55 Repro-Cessation	50	Yes	EC	Unknown	22	8	7
426	Male	35-44 Mature Adults	40	Yes	OTHER	Unknown	29	1	14
428	Male	25-34 Adults	30	No	LE	Unknown	20	1	3
429	Male	15-24 Young Adults	20	Yes	LE	Unknown	28	0	0
436	Male	45-55 Repro-Cessation	45	No	HA	Unknown	6	0	0
437	Male	45-55 Repro-Cessation	50	Yes	EC	Late Cienega	26	4	8
438	Male	25-34 Adults	30	No	EC	Unknown	12	2	2
445	Male	25-34 Adults	27	Yes	HA	Early Cienega	9	0	1
464	Male	15-24 Young Adults	20	Yes	LE	Unknown	25	0	0
480	Male	25-34 Adults	25	Yes	EC	Unknown	26	4	2
485	Male	25-34 Adults	30	Unknown	LE	Unknown	3	0	0
491	Male	25-34 Adults	25	Unknown	EC	Unknown	27	0	0
497	Male	35-44 Mature Adults	35	Yes	EC	Unknown	10	3	5
498	Male	45-55 Repro-Cessation	45	Yes	LE	Unknown	17	5	0
499	Male	15-24 Young Adults	16	Yes	LE	Unknown	32	0	0
501	Male	45-55 Repro-Cessation	50	No	LE	Unknown	19	2	0
503	Male	35-44 Mature Adults	40	Yes	LM	Unknown	9	1	2
504	Male	45-55 Repro-Cessation	50	Yes	LM	Unknown	29	0	4

APPENDIX B

DENTAL RECORDING CODES

Permanent Dentition #1-32 (from maxillary right 3rd molar [1] to the mandibular right 3rd molar [32])
Deciduous Dentition #51-70

Dental Inventory (P/A): (Buikstra and Ubelaker 1994)

1. Present, but not in occlusion (record stage of crown/root formation under "Development")
2. Present, development completed, in occlusion
3. Missing, with no associated alveolar bone
4. Missing, with alveolus resorbing or fully resorbed: antemorten loss
5. Missing, with no alveolar resorption: postmortem loss
6. Missing, congenital absence
7. Present, damage (no measurements possible) but other observations recorded
8. Present, but unobservable(e.g. deciduous or permanent tooth in crypt)
9. Present, but lost from socket (loose tooth)

Development: (Moorees et al. 1963) **If deciduous dentition**

1. Initial cusp formation
2. Coalescence of cusps
3. Cusp outline complete
4. Crown ½ complete
5. Crown ¾ complete
6. Crown complete
7. Initial root formation
8. Initial cleft formation
9. Root length ¼
10. Root length ½
11. Root length ¾
12. Root length complete
13. Apex ½ closed
14. Apex closed

Caries: (Moore and Corbett 1971) *If more than three caries are present divide recording boxes in half with a slash

0. No lesion present or Unobservable
1. Occlusal surface (all grooves, pits, cusps, dentin exposures, and the buccal and lingual grooves of the molars)
2. Interproximal surfaces (includes the mesial and distal cervical regions)
3. Smooth surfaces (buccal [labial] and lingual surfaces other than grooves)
4. Cervical caries (originates at the cemento-enamel junction [CEJ], except the interproximal regions)
5. Root caries (below the CEJ)
6. Large caries (cavities that have destroyed so much of the tooth that they cannot be assigned a surface of origin)
7. Noncarious pulp exposure (exposed pulp chamber)

Abscess: (Buikstra and Ubelaker 1994)

0. Absent or Unobservable
1. Buccal or labial alveolar channel
2. Lingual alveolar channel

Calculus: note surface affected (buccal/labial or lingual) (Buikstra and Ubelaker 1994)

0. Absent or Unobservable
1. Small amount
2. Moderate amount
3. Large amount

Chipping:

0. Absent or Unobservable
#. number of chips in enamel

Periodontal Disease:

0. Absent or Unobservable
1. Mild, some cortical thinning, porous appearance
2. Severe, alveolar remodeling, exposure of root and cancellous bone

Enamel Defects (Hypoplasias and Opacities): (Buikstra and Ubelaker 1994, Rose et al. 1985; Goodman & Rose 1990)

Defect: Number (#) of defect on tooth (e.g. 1, 2, etc.)

0. Absent or Unobservable
1. Linear horizontal grooves
2. Linear vertical grooves
3. Linear horizontal pits
4. Nonlinear arrays of pits
5. Single pits
6. Discrete boundary opacity
7. Diffuse boundary opacity

Location: Distance from mid-point of the labial/buccal CEJ to the most occlusal portion of the hypoplasia.
Color: 1. Yellow, **2.** Cream/White, **3.** Orange, **4.** Brown

Attrition: (Buikstra and Ubelaker 1994)

Incisors and Canines: (Smith 1984)

0. No information available (not occluding, unerupted, antemortem or postmortem loss, etc.).
1. Unworn to polished or small facets (no dentin exposure).
2. Point or hairline of dentin exposure.
3. Dentin line of distinct thickness.
4. Moderate dentin exposure no longer resembling a line.
5. Large dentin exposure with enamel rim complete.
6. Large dentin area with enamel rim lost on one side or very thin enamel only.
7. Enamel rim lost on two sides or small remnants of enamel remain.
8. Complete loss of crown, no enamel remaining; crown surface takes on shape of roots.

Premolars: (Smith 1984)

0. No information available (not occluding, unerupted, antemortem or postmortem loss, etc.).
1. Unworn to polished or small facets (no dentin exposure).
2. Moderate cusp removal (blunting).
3. Full cusp removal and/or moderate dentin patches.
4. At least one large dentin exposure on one cusp.
5. Two large dentin areas (may be slight coalescence).
6. Dentinal areas coalesced, enamel rim still complete.
7. Full dentin exposure, loss of rim on at least one side.
8. Severe loss of crown height; crown surface takes on shape of roots.

Molars (add scores for all 4 molar quadrants to record totals): (Scott 1979)

0. No information available (not occluding, unerupted, antemortem or postmortem loss, etc.).
1. Wear facets invisible or very small.
2. Wear facets large, but large cusps still present and surface features (crenulations, noncarious pits) very evident. It is possible to have pinprick size dentine exposures or dots which should be ignored. This is a quadrant with much enamel.
3. Any cusp in the quadrant is rounded rather than being clearly defined as in 2. The cusp is becoming obliterated but is not yet worn flat.
4. Quadrant is worn flat (horizontal) but there is no dentine exposure other than a possible pinprick sized dot.
5. Quadrant is flat, with dentine exposure ¼ of quadrant or less (do not confuse noncarious pits with dentine exposure).
6. Dentine exposure greater: more than ¼ of quadrant is involved, but there is still much enamel present. The dentine patch is surrounded on all three sides by a ring of enamel.
7. Enamel is found on only two sides of the quadrant.
8. Enamel on only one side (usually outer rim) but the enamel is thick to medium on its edge.
9. Enamel on only one side as in 8, but the enamel is very thin—just a strip. Part of the edge may be worn through at one or more places.
10. No enamel on any part of the quadrant—dentine exposure complete. Wear is extended below the CEJ into the root.

Angle: (Smith 1984)

- Visual approximation drawn on tooth graphic.
- Measure the angle of the occlusal wear plane surface relative to a horizontal occlusal plane surface with bar protractor to nearest 0.5°. Slopes to the buccal are arbitrarily designated as positive and slopes to the lingual are designated as negative (Smith 1984).
- Measured on occluding surfaces on upper and lower teeth: on the talonid basin of mandibular molars and across the trigone of maxillary molars.
- Unworn teeth are measured from cusp to cusp, not from cusp to fossa.
- Both teeth must be in place in bone, and teeth partly extruded from their sockets during life, obviously dislocated, or virtually destroyed by dental caries cannot be measured.
- **NA**. Unobservable

Measurements: (Mayhill 1992)

*Record left side of dental arcade, substitute antimere when left not observable.

Mesiodistal Diameter: Maximum width of the tooth crown in the mesiodistal plane. When severe molar wear prevents accurate measurement measure interproximal contact points parallel to the occlusal surface.

Buccolingual Diameter: Measured as the widest diameter of the tooth, perpendicular to the mesiodistal plane (in molars, usually about ½ the distance between the CEJ and the occlusal surface).

Crown Height: Measured from the occlusal surface to the CEJ on incisors, canines, and premolars. In molars it is the distance between the tip of the mesiobuccal cusp to the CEJ, measured along a line parallel to the long axis of the tooth.

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APPENDIX C

LA PLAYA DENTAL ANALYSIS RECORDING FORM

Age:	Sex:		Recorder:	Date:

Right / Left

MAXILLA	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	M3	M2	M1	PM2	PM1	C	I2	I1	I1	I2	C	P1	P2	M1	M2	M3
P/A																
Caries																
Abcesses																
Calculus																
Chipping																
Periodontitis																
Attrition Score																
UL Quad Score																
UR Quad Score																
LR Quad Score																
LL Quad Score																
Angle Descrip.																
Attrition Angle																
Attrition Meas.																
UL Cusp Meas.																
UR Cusp Meas.																
LR Cusp Meas.																
LL Cusp Meas.																
M-D Dia.																
B-L Dia.																
MANDIBLE	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
	M3	M2	M1	PM2	PM1	C	I2	I1	I1	I2	C	P1	P2	M1	M2	M3
P/A																
Caries																
Abcesses																
Calculus																
Chipping																
Periodontitis																
Attrition Score																
UL Quad Score																
UR Quad Score																
LR Quad Score																
LL Quad Score																
Angle Descrip.																
Attrition Angle																
Attrition Meas.																
UL Cusp Meas.																
UR Cusp Meas.																
LR Cusp Meas.																
LL Cusp Meas.																
M-D Dia.																
B-L Dia.																

Comments:

Age: Sex:

Recorder: Date:

	Right															Left
MAXILLA	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
	M3	**M2**	**M1**	**PM2**	**PM1**	**C**	**I2**	**I1**	**I1**	**I2**	**C**	**P1**	**P2**	**M1**	**M2**	**M3**
Winging																
Labial curve																
Shovel																
Double shovel																
Interrup. Groove																
I & C t.d																
C mesial ridge																
C d.a.r.																
P m. & d. cusps																
Metacone						Uto-Aztec P				Uto-Aztec P						
Hypocone																
Cusp 5																
Carabelli																
C2 parastyle																
Enamel ext.																
Root number																
Radical number																
Peg (<7)/reduce																
Odontome																

MANDIBLE	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**
	M3	**M2**	**M1**	**PM2**	**PM1**	**C**	**I2**	**I1**	**I1**	**I2**	**C**	**P1**	**P2**	**M1**	**M2**	**M3**
Shovel																
C d.a.r.																
P ling. cusps	Anterior fovea														Anterior fovea	
Groove pattern																
M cusp no.																
Deflect wrinkle																
C1-C2 DT crest																
Cusp 5																
Cusp 6																
Cusp 7						Tomes					Tomes					
Enamel ext.																
Root number																
Radical number																
Odontome		Torsomolar												Torsomolar		

Comments:

Max. Torus:
Mand. Torus:
Rocker Mand.:
Extra Teeth:
TMJ damage:

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