SEX DIFFERENCES IN DENTAL LESIONS AT TEPE HISSAR DURING PERIODS OF STRESS

by

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A thesis submitted to the Faculty of the University of Delaware in partial fulfillment of the requirements for the degree of Degree in Major with Distinction

Spring 2017

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ACKNOWLEDGMENTS

Firstly, I would like to thank the University of Delaware for giving me opportunities I otherwise would have never dreamed. Both the Undergraduate Research Department and the Department of Anthropology have supported and funded my research every step of the way, offering sage advice and understanding when my own shortcomings as a student and a researcher threatened my work. In particular, I would like to thank Dr. Karen Rosenberg for fostering my interest in biological anthropology, and undertaking this journey with me, giving me the tools to pursue this research project, and the resources and connections to take my career beyond this point. I would also like to thank Dr. Lauren Barsky of the undergraduate research department for replying to my late-night emails with good humor and even better information, and allowing me to interrupt her lunch more than once.

I would like to thank the University of Pennsylvania for opening their doors and bone cabinets to me, allowing me to collect my very own dental data for this thesis. I would like to thank Dr. Janet Monge who warmly invited me into her lab and gave me every resource I could ever possibly need. This thesis would have never come to fruition without her generosity.

Finally, I would like to thank the American Association of Physical Anthropologists (AAPA) for giving me the opportunity to present my research and

findings at the undergraduate research symposium of the 87th annual AAPA conference. This experience has helped shaped not only my research, but also my own pursuit of a career in biological anthropology.

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ABSTRACT

Cross-culturally, women often have lower social status than men and this may be manifest in differences in health. In many societies females display a greater prevalence of caries than males, suggesting poorer dental health. However, no clear pattern has been established for sex differences in linear enamel hypoplasia (LEH) an independent indicator of stress. The dentition is the only part of the skeleton that directly interacts with the environment (Guatelli-Steinberg, 2016). Dental health is one way of examining the social and economic status of individuals within a culture. In many societies females display greater prevalence of dental caries (CAR) than males, suggesting poorer dental health, and potentially a lower social status. However, no clear pattern has been established for sex differences in linear enamel hypoplasia (LEH) an independent indicator of stress. In this thesis, I explore sex differences in LEH and CAR at the prehistoric Tepe Hissar site (located in the north-eastern Central Iranian Plateau) to examine sex differences in health and in social status. I examine dental lesions such as linear enamel hypoplasia, dental caries, and abscesses, and infer sex differences in stress and the different life experiences of men and women through time. 71 individuals from Tepe Hissar were macroscopically analyzed for LEH, carious lesions, and abscesses, and dental measurements were taken following Buikstra and Ubelaker (1994). The only statistically significant sex difference was in linear enamel hypoplasia (found via a chi-square test at a .05 confidence level). The females displayed a higher presence and prevalence of LEH than their male counterparts, according to a chi-squared test. Dental caries and abscesses had no statistically significant findings. Males and females had similar average ages for LEH development on canines and molars. These data illustrate more LEH in females, indicating that males may have been favored, even during periods of stress. This conclusion is corroborated by higher rates of tooth loss and osteoporosis in females. This finding helps us to understand sex differences in stress indicators, sex, and societal status.

Chapter 1

INTRODUCTION

In all cultures, men and women have different life experiences. These differences between the sexes arise from a combined cultural and biological influence. One way to study these differences is through dental health. In prehistoric populations, dental remains are a particularly useful subject of study since teeth tend to be the most commonly preserved element of the human skeleton. The field of dental anthropology utilizes information obtained from the teeth of either skeletal or living human populations to answer anthropological questions (Scott & Turner, 1988: 1). Dental anthropological researchers have recognized that in living and past populations, females often display a higher frequency of dental defects than males (Guatelli-Steinberg & Lukacs, 1999; Hillson, 2002, 2014; Irish & Nelson, 2008). While scholars have not been able to settle on a concrete theory explaining the causes of this phenomenon, it is believed that the difference is due to a complex interaction between cultural practices that result in the differential treatment of men and women, and the biological stress that results.

An excellent opportunity to study the question of dental health as it relates to sex differences and stress is the Tepe Hissar prehistoric skeletal assemblage, excavated from the north-eastern Central Iranian Plateau, and dated to the Chalcolithic and Bronze Ages (late 5th to early 2nd millennium BC). While many of the skeletal remains from Tepe Hissar were poorly preserved, the assemblage has a large portion of both articulated and disarticulated teeth in good condition. Samples of teeth from the assemblage have also previously been analyzed by Hemphill (2008), and Afshar (2014). Hemphill found a statistically significant difference between the linear enamel hypoplasia rates of the sexes, with females having a higher frequency of linear enamel hypoplasia than males. However, Afshar (2014) found a pattern of higher rates of linear enamel hypoplasia within females in each of the three Hissar periods (discussed in further detail in Chapter 2), but it was not statistically significant. This study explores sex differences in dental health in the Tepe Hissar assemblage; specifically, this research explores sex differences in rates and severity of linear enamel hypoplasia, dental caries, and abscesses.

Carious lesions are a "destruction of the enamel, dentine, and cementum resulting from acid production by bacteria in dental plaque" (Hillson, 2014: 269), which ultimately leads to a cavity, most commonly in the crown or within the root system. For all types of carious lesions, a characteristic pattern is found in human populations; the molars are usually the most commonly affected, with the premolars and anterior teeth coming second and third respectively (Hillson, 2014). Frequently, carious lesions are the result of diets high in carbohydrates, because a carbohydrate-rich diet creates an oral environment conducive to cariogenic bacteria. However, the influence of proteins on the development of caries is not well known. In general, differences in caries rates are interpreted as indicative of differences in diet.

Linear enamel hypoplasia is a “deficiency of enamel thickness, disrupting the contour of the crown surface, initiated during the enamel matrix secretion” (Hillson, 2014:165). There are several different forms of enamel hypoplasias, with linear EH being the most common. These LEH lesions are typically arranged around the crown in lines resembling the perikymata. In both living and ancient populations of humans and animals, LEH have long been recognized as indicators of general stressors on health. Abscesses, or periapical lesions are caused by bacterial induced inflammation of the pulp cavity ultimately leading to death of the cavity and a sinus on the surface of the alveolar wall (Ogden, 2008).

1.1 Background to the project

Tepe Hissar is located in the north-eastern Central Iranian Plateau, between major trade routes along the “Silk Road”, and the Caspian Sea. The site is comprised of seven disconnected mounds and flat settlements which are approximately 600 meters in diameter each. In addition to an optimal landscape and water sources, Tepe Hissar also has an abundance of natural resources, with the diet of the population being comprised mostly of species of domesticated wheat, barley, and lentils combined with wild grapes and olives. This diet was supplemented by meat from caprines and cattle. The archaeological excavations of Tepe Hissar revealed that the site is defined by three distinct periods, referred to as Hissar I, II, and III. The Hissar I period is characterized by the sudden appearance and expansion of the settlement in the late 5th millennium BC. The original settlers of Tepe Hissar were most likely immigrants from previously abandoned sites, who gravitated toward Tepe Hissar due to its favorable placement between trade routes and a water source.

During the late Hissar I period (mid-early 4^{th} millennium BC), archaeological evidence in the form of the appearance of "grey pottery" and the disappearance of the traditional "painted pottery" indicates a significant cultural shift at the site. Archaeological evidence of fire and ash, as well as burnt human remains and the destruction of buildings dated to this period indicate that the cultural shift was probably a violent and traumatic one. The leading theory on the shift between Hissar I and II states that Hissar II people migrated to the site from the Turkmenistan Steppes (Schmidt, 1937), and had a traumatic and potentially violent encounter with the Hissar I people inhabiting the area. Archaeological evidence, such as changes in pottery design and decoration, and changes in the settlement area of Tepe Hissar suggests that the influx of new peoples into the site may have caused a fracture within the close community and culture of the population, and that many of the Hissar I people left the site, headed toward the western regions of Iran (McCown, 1942).

The transition between Hissar II and Hissar III shows evidence of another cultural shift. The second cultural shift is not indicated by a shift in pottery, as the grey pottery is still the staple of the Hissar III people. Rather, the second cultural shift is indicated by the burning and destruction of buildings, charred human skeletal remains, and particularly the presence of mass burials in the middle to late Hissar III period (Schmidt, 1933, 1937). Archaeologists who interpreted the evidence from the site suggest that the second cultural shift suffered from inter- or intra-group conflict and violence instead of the violence that came from the migration of new peoples in the first cultural shift.

The upheaval caused by cultural shifts, migrations, and violence, which could have led to physiological stress is significant to the dental anthropology of the Tepe Hissar assemblage. In general, the focus of this study is to determine if there is a sex difference in the rates and severity of linear enamel hypoplasia, dental caries, and abscesses. The presence and sex distribution of these dental lesions can lend invaluable insight into the stress experienced by the males and females of Tepe Hissar. Archaeological context coupled with this insight may illuminate the cause of the stress, if it is present.

1.2 Hypothesis and Research Questions

1.2.1 Hypothesis

Males and females were treated differently through cultural practices, leading to a greater biological stress in females, the consequences of those differences would show up on the teeth. The three main dental pathologies chosen to measure this are linear enamel hypoplasia, dental caries, and abscesses. The most violent cultural shifts occurred in Hissar III, and the population likely experienced the most stress during this period, therefore LEH, CAR, and AB will be greater overall, and likely greater in females.

Questions

1. Is there a statistically significant difference in LEH, CAR, and/or AB between the males and females of the sample?

2. Is there a higher presence and/or frequency of LEH, CAR and/or AB within the Hissar III period?

3. If so, which sex has the higher presence and/or frequency of these dental lesions and defects?

4. Is there a statistically significant difference in the skeletal lesions on the males and females that denote workload and lifestyle?

1.3 Significance of Research

Dental anthropology can illuminate some aspects of the differing life experiences of the sexes through time. It can show the health effects of sex-specific cultural practices, and biases toward one sex over another. It can also help researchers understand female resilience, and the effects of the stress on health, as well as how that stress manifests itself in skeletal remains.

1.4 Structure of the Thesis

This thesis is organized into 7 chapters. This first chapter has introduced the research, and Tepe Hissar site, as well as the hypotheses and their respective research questions, and the significance and implications of the project. The second chapter will give an overview of the archaeological context of the Central Iranian Plateau and, more specifically, Tepe Hissar. This archaeological context includes geographical context, the prehistoric chronological sequence of Tepe Hissar, the graves at the site and the mortuary practices, as well as a short summary of the paleopathology of the skeletal remains, not including the teeth, which will be discussed in detail in chapters 5 and 6. Chapter 3 will discuss how the field of Dental Anthropology can help us elucidate the remains from Tepe Hissar, particularly focusing on dental caries and linear enamel hypoplasia. Chapter 4 will discuss the research methods and materials used to collect data on the dental health of the Tepe Hissar assemblage, and chapter 5 will give a detailed summary of the results of the research. Chapter 6 and 7 will discuss those results, with chapter 6 investigating the evidence of female buffering as a biological reason for the differences seen between men and women in terms of linear enamel hypoplasia, and discussing the differing life histories of men and women at the Tepe Hissar site, as evidenced by the paleopathology profile of the site. Chapter 7 will return to the hypotheses outlined in this chapter, and answer the research questions associated with them, as well as give my ultimate conclusions from the research, and avenues for future research.

Chapter 2

THE ARCHAEOLOGICAL CONTEXT OF THE CENTRAL IRANIAN PLATEAU AND TEPE HISSAR

2.1 Geographical Context

The first residents of the Tepe Hissar site were most likely agricultural people whose origin and language is unknown, and for which there are no written records. The area was first inhabited because of the abundance of natural resources available. The high valleys in the northern part of Tepe Hissar are rich in flint, lead, wood, fruit, and animals such as deer, stag, boar, fish, and fowl. In the southern parts of the region, copper, gold, turquoise, and herds of gazelles and onagers dominate the landscape. Ecological studies show that the landscape was fertile for agriculture and optimal for settlement even in the Chalcolithic and Bronze Age periods (Meder, 1989). The earliest people at Tepe Hissar had both plants and animal domesticates, as evidenced by the archaeobotanical material found at the site, including chaff fragments, legumes and fruits, and faunal remains, of which 72.7% were domestic animals (Afshar, 2014).

2.2 Prehistorical Chronological Sequence of Tepe Hissar

As mentioned in the "Introduction" section, the occupancy of the Tepe Hissar site ranges between the late 5th to the early 1st millennium B.C. During the earliest excavations of the area in the 1930s, the site was divided into three major periods using differences in archaeological raw materials to distinguish them. The first period, named “Hissar I” is the Early Chalcolithic period, which is characterized by “painted” pottery. Burnished black and grey pottery indicate the presence of the second and third periods, named “Hissar II” and “Hissar III”, and broadly dated to the Bronze Age and Iron Age. All the information about these periods at Tepe Hissar are taken from *The New Chronology of the Bronze Age Settlement of Tepe Hissar, Iran* by Ayse Gürsan-Salzmann (2016).

2.2.1 Hissar I Period (ca. 4300–3700 B.C.)

Stratigraphically, Hissar I is represented by a relatively thick deposit with several occupation levels, indicating that there was continuous occupation of the site throughout the period. The architecture revealed from excavations suggests that the first settlers of the site were already sedentary, building small to medium sized houses made from sun-dried bricks. The excavations also revealed evidence of considerable wealth and craft specialization on the part of the first settlers at Tepe Hissar. Overall, the archaeological data suggest that the economy of the Hissar I period was based on agriculture, herding, metal and stone working, and pottery. At the end of Hissar I a new style of pottery emerges, denoted by archaeologists at the black burnished and grey pottery. This emergence of new pottery overlaps into Hissar II. Researchers and archaeologists theorize that this overlap could indicate the infiltration of “grey ware” peoples into the Tepe Hissar site, and/or the movement of Tepe Hissar natives into the region of Giyan as the “grey ware” peoples move into Tepe Hissar.

2.2.2 Hissar II Period (3700–2900 B.C.)

As stated above, the main diagnostic artifact of Hissar II is the burnished black and grey pottery. Generally, occupation levels for Hissar II within the stratigraphy were thinner than those for both Hissar I and III. The archaeological markers delineating Hissar Period II began in the Late Chalcolithic and continue until late Early Bronze I (Fazeli et al., 2009; Thornton, 2009). The houses in Hissar II were markedly different from those in Hissar I, with sophisticated craftsmanship and a planned architecture that incorporated storage space, whereas previously the houses only had enough room for people to sleep.

The greyware that defines Hissar II was also used to divide the period into two phases, with an earlier period and a later period (Dyson, 1987). The archaeologists that originally excavated Tepe Hissar interpreted the changes in the earlier period as indicative of the arrival of a new people, an interpretation supported in more recent analyses. The cultural transition, indicated by the change in pottery and the potential arrival of new people, was most likely not peaceful and possibly stressful. The archaeological restudy of Tepe Hissar conducted in 1976 found evidence of several buildings being burned and destroyed near the beginning of the later phase in Hissar II. There was another building destroyed by fire at approximately the same time as the others, but in a different part of the site. The burned and scattered skeletal remains of a child were found within this burned building, with fragments of pottery dating to the beginning of the later phase in Hissar II. The cultural shift, arrival of new people, and the burned and destroyed remains of several buildings within this period are all evidence which suggest the Hissar II period was a stressful one for the occupants, and this may have been expressed within their skeletal and dental lesions.

2.2.3 Hissar III Period (2900–1800 B.C.)

The third and final Hissar Period is dated to the Early Mid Bronze Age, and is distinguished from the other periods through several archaeological diagnostic artifacts, the most basic being the presence of only burnished grey pottery in most burials dated to this period. The occupation layer for this period was also thicker than both Hissar I and II, but archaeological evidence indicates that the population lived in more compact, organized areas. Hissar Period III is separated into 3 distinct phases, Hissar IIIA, Hissar IIIB, and Hissar IIIC, and the occupation is dense in Hissar IIIB (2500–2200 B.C.). Archaeological analysis provides evidence that Hissar III (particularly Hissar IIIB) was characterized by intensive craft specialization and social differentiation. Craft specialization was found in metallurgy, stone and bone working, and pottery making, among others, and was tied to the appearance of multifunction activity areas (workshops) around the site. These specializations most likely occurred simultaneously for at least the length of one period.

However, these changes in complexity, social strata, and craftsmanship may have come at a cost, which is exemplified by the Burned Building dated to approximately 2420-2290 B.C. Archaeological evidence suggests that the Burned Building was one of the largest buildings at Tepe Hissar, with 6 different rectangular rooms, storage rooms, staircases, and several hearths and ovens. It was built with great care and a complex building plan, which included a tower protecting the entrance. The building was ultimately destroyed by fire and several charred human remains were found in different parts of the building, along with a large quantity of flint arrowheads found both inside and outside of the building, and 7 copper daggers found inside the building. Due to the large size of the building and the complexity of its design, and the defensive tower outside what was likely the main entrance, it may have been occupied by a prominent family within Tepe Hissar during this period, or it may have been used for religious purposes. Whatever the purpose of the building, archaeological evidence suggests that it was the site of a deadly cultural conflict, indicating that the significant changes occurring at the site during Hissar III were most likely highly stressful, and may have had considerable effects on the health and diet of the overall population.

The final period of the Tepe Hissar occupation ends abruptly in the late 3rd millennium B.C. with what was most likely a hostile invasion from the east (Schmidt, 1933; Bovington et al., 1974). This was contemporary with similar events occurring at Yarim Tepe and Turang Tepe in the Gorgan plain. Specific archaeological finds denoting Central-Asian culture in the burials and hoards from the end of Hissar III indicate immigration of peoples from the east (Sarianidi, 1981).

2.3 Tepe Hissar Graves, Death, and Burial Culture

Mortuary practices during all three periods of the Tepe Hissar occupation consisted of both simple inhumation of individuals, and multiple burials. Peoples of all periods of Tepe Hissar were buried in one mound area designated by the archaeologists as the Main Mound, but graves were found to a lesser extent in other areas as well, which were designated North Flat, South Hill, and Treasure Hill. The burials themselves did not seem to have a specialized area, but were instead placed under rooms in houses, below courtyards and lanes, and in uninhabited or undeveloped spaces.

There is no evidence that individuals were buried differently according to age or sex. However, there were several types of burials, with pit burials and communal chamber burials being the most common. The pit burials consisted of the remains being wrapped in woolen garments (which was common in all types of burials) and interred in plain soil. The communal chamber burials were any burials that held more than one set of remains, but for which the stratigraphy indicates that the bodies were interred at different times (i.e. not a mass burial). Group burials at Tepe Hissar also typically show little to no signs of disarticulation, as is common in the mass burials. Several small mass burials were found throughout the three Hissar periods, but the largest one by far was dated to the late Hissar II to Hissar III period. Archaeologists from both the original excavations in the 1930s, and those from the re-excavations of the 1970s agree that group burial was a common and significant practice during the late Hissar II to the Hissar III period.

2.4 Non-Dental Paleopathology of Tepe Hissar

The average age of the Tepe Hissar population was approximately 27.5 years old, with the average age at death for adults between 29 to 32 years of age (Nowell, 1989). Afshar (2014) did a basic mortality profile for each of the three Hissar periods and concluded that younger females (between the ages of 18-25) died in Hissar I and II than in Hissar III. The mortality rate for the first two periods was also higher than in Hissar III. Slightly older females (between the ages of 26-35) were at a higher risk of death in Hissar III than in Hissar I or II (Afshar, 2014: 289). The mortality profiles Hissar I and II follow the same basic pattern; young females (18-25) are at a higher risk of death than their male counterparts, but in contrast, slightly older males (26-35) are at a higher risk of death than their female counterparts. As individuals age, their risk of death by unnatural causes steadily decreases, which is especially true for females. Hissar III is seemingly the reverse of this pattern, with fewer young females dying, but with elder females (50+) having a higher risk of death.

The total percentage of metabolic diseases found in males and females across all Hissar periods are remarkably similar, with females having slightly higher percentages for certain diseases. Afshar (2014) analyzed a sample of the Tepe Hissar assemblage for cribra orbitalia, porotic hyperostosis, vitamin C deficiency, total vitamin D deficiency, residual rickets, and osteoporosis. Neither males nor females had a prevalence of vitamin C deficiency over 1% (Afshar, 2014). Females, across all Hissar periods, had slightly higher percentages of cribra orbitalia and osteoporosis than males. Males, across all Hissar periods, had slightly higher percentages of porotic hyperostosis and residual rickets than females, but the difference was not statistically significant (Afshar, 2014). Overall, 75% of the population of females across all time periods of Tepe Hissar had some form of metabolic disease, while 69% their male counterparts had some form of disease.

2.5 Short Summary of the Chapter

No written record remains from the inhabitants of Tepe Hissar, archaeobotanical evidence and faunal analysis revealed that the inhabited area was abundant in natural resources and the soil was fertile for agriculture. The site was divided chronologically into three major periods: Hissar I, II, and III. Near the end of Hissar I and overlapping with Hissar II is the first indication of a cultural shift, in the form of new black burnished and grey pottery. There is no archaeological evidence to suggest that this transition was a violent one. The pottery changes again during Hissar II, dividing the period into earlier and later sections. The pottery change in the later section of Hissar II is accompanied by burned and destroyed buildings as well as the burned and scattered remains of a child. The Hissar III period is separated from Hissar II through several diagnostic archaeological artifacts, the main one being the presence of only the black burnished pottery, and the absence of the grey pottery, or any other style or type of pottery. Hissar III was typified by intense craft specialization and more organized and compact living sites; it also has less egalitarianism and more social stratification. It may have also been marked by the most intense inter- and intrapersonal violence and destructiveness reactions to the cultural shifts. This is exemplified by the Burned Building, which showed evidence of a violent attack and ultimate destruction. A sort of mini battle seems to have taken place, with several arrowheads, copper daggers, and charred human remains found inside and in the proximity of the building. The denouement of the Tepe Hissar settlement concluded with an invasion of the site, likely from the east and the abrupt end of the original population.

The violent cultural transitions of Tepe Hissar can be tracked, in part, through the burial styles throughout the three periods. The most common burial styles for all three periods were pit burials and communal chamber burials. The pit burials consisted of one set of human remains wrapped in woolen material. The communal chamber burials had at least 2 sets of human remains, but for which the stratigraphy indicated that the bodies were interred at different times. The communal chamber burials were differentiated from the mass burials stratigraphically. The communal chamber burials also showed little to no disarticulation in the remains, unlike the mass burials. Mass burials were found scattered throughout all three periods, but they were the most numerous with the greatest number of human remains in Hissar III, denoting the particularly violent cultural transition that took place during that time.

In addition to violence, the inhabitants of Tepe Hissar contended with various metabolic diseases as well. Overall, 75% of the population of females across all time periods of Tepe Hissar had some form of metabolic disease, while 69% their male counterparts had some form of disease. There were certain diseases that were more prevalent in males or females, but none of these differences were statistically significant.

Chapter 3

BACKGROUND: SKELETAL AND DENTAL LESIONS AND STRESS

3.1 Stress and Disease

Physical anthropologists define "stress" as the physiological result of a repeated negative environmental variable on both individuals as well as populations (Buikstra & Cook, 1980; Goodman et al., 1988; Bush & Zvelebil, 1991). These environmental variables can sometimes be read indirectly on the bones and teeth through skeletal lesions and are generally caused or exacerbated by food shortages, famines, disease and viruses, changes in subsistence patterns, or by social issues such as a change in socio-cultural structures, changes in lifestyle and economy, changes in political stability, or migration or emigration. These variables are not mutually exclusive, for example famine can lead to political instability and vice versa.

The level to which certain economic groups, ages, and sexes are affected by stressors such as the ones listed above can be investigated through the dental and skeletal lesions that the stressors leave behind. Bone formation is caused by mineralization of new bone growth through osteoblasts, and is remodeled through the simultaneous work of bone resorption and bone replacement (Turner & Walker, 2008). Skeletal lesions are simply abnormal bone formations, causing abnormal densities, sizes, or shapes to the bone (Ortner, 2003). Skeletal lesions may be the result of a combination of several diseases, infections, and stressors on the body, or may represent only one stressor. Specific diseases and infections which have been shown to cause skeletal lesions are such things as scurvy (Maat, 2004), rickets and osteomalacia (Brickley et al., 2007), and osteoporosis (Mays et al., 2006).

3.2 Skeletal Lesions

The most common of skeletal pathologies found in both living and archeological populations is osteoporosis (Marcus & Bouxsein, 2013). Osteoporosis is characterized by a steady decrease in bone mineral density (BMD) and bone mass, especially with age, that causes the risk of fracture. It is a chronic disease the affects millions of people, and is frequently seen in archaeological populations (WHO, 2007; Holick, 2007; Waldron, 2009). Osteoporosis it caused by multiple factors, including vitamin C and D deficiency (which I will discuss in more depth later in this section), malnutrition in early life, low calcium intake, parasites, sedentary lifestyles, many pregnancies, prolonged lactation and hormonal differences in males and females (WHO, 2003; Matkovic & Landoll, 2004; Rauch & Glorieux, 2004; Marcus & Bouzsein, 2013). Osteoporosis can also be caused by genetic factors, but to a lesser extent than by the environment.

The inadequate intake of vitamin D, either through diet or sun exposure, causes systemic disease of early childhood and adulthood such as rickets and osteomalacia, which in nearly all cases causes a skeletal lesion (WHO, 2003). A lack of vitamin D negatively impacts the activity of osteoblasts, causing inadequate mineralization and the softening of bones (Chaplin & Jablonski, 2009) which manifests as a physical lesion on the skeleton. Vitamin D helps the human body to provide immune reactions, lung function, mineral metabolism, and cancer protection, as well as playing a role in stimulating growth (Holick, 2008; Valdivielso & Ayus, 2008). An inadequacy of vitamin D could be caused by, a lack of sun exposure, which might be caused by particular clothing styles, skin color, urbanization, and occupational hazards can have an impact as well (WHO, 2003; Chaplin & Jablonski, 2009). Not all causes of vitamin D deficiency are environmental, however; it can be caused by genetic factors, as well as passed from mother to infant, handicapping the infant into childhood (Weisz & Albury, 2013).

Recent clinical studies on modern Middle Eastern populations suggest that sunlight exposure cannot be the only cause or factor considered when interpreting vitamin D deficiency in both living and ancient populations. El-Hajj Fuleihan (2010) found a high prevalence of rickets, osteomalacia, and osteoporosis in a modern Middle Eastern population, concluding that a complex amalgam of nutritional deficiency, dark skin color, and low socio-economic status may be the cause of the disorders resulting from vitamin D deficiency.

There are also “non-specific” indicators of stress, meaning that a precise disease or infection cannot be pinpointed as the cause. These types of stressors include porotic hyperostosis of the skull and cribra orbitalia, which are well known and among the most frequent skeletal lesions in ancient remains (Walker et al., 2009). Porotic hyperostosis and cribra orbitalia both manifest themselves as a “porosity” in the bones of the skull cap, particularly the frontal, parietal, and occipital bones, which will present with small holes that penetrate the bone (Schultz, 2001). Some researchers consider porotic hyperostosis and cribra orbitalia one and the same, while other suggest that the two may have different etiologies (Walker et al., 2009). General anemia is the mostly frequently cited cause of these skeletal lesions, but genetic factors (Larsen, 1997), nutrition, vitamin deficiency, parasites such as malaria or hookworm (Roberts & Manchester, 2005), and the comorbidity of rickets and scurvy (Roberts & Manchester, 2005) are all possible causes as well.

Porotic hyperostosis and cribra orbitalia have been shown to be more frequent in the Neolithic period than the Palaeolithic or Mesolithic (Meiklejohn et al., 1984). The increase in the rate of these skeletal pathologies may have been the result of anemia and other diseases, which may have been the result of the population growth, increased sedentism, and the new reliance on grain foods (Stuart-Macadam, 1992).

3.3 Dental Indicators of Stress

The dentition is the only part of the skeleton that directly interacts with the environment (Guatelli-Steinberg, 2016). Due to the unique role of the teeth, along with their incredible resistance to destruction during taphonomic or fossilization processes, teeth can provide bioarchaeologists with a nearly unparalleled amount of information on growth and development, dietary and subsistence patterns, overall heath, and even cultural practices. In this study, all maxillary and mandibular teeth, roots, and sockets (both articulated and disarticulated) were macroscopically examined for linear enamel hypoplasia (LEH), dental caries (CAR), calculus (CAL), abscesses (AB), and ante-mortem tooth loss (AMTL).

3.3.1 Linear Enamel Hypoplasia

Linear enamel hypoplasia is a "deficiency of enamel thickness, disrupting the contour of the crown surface, initiated during the enamel matrix secretion" (Hillson, 2014:165). Enamel hypoplasias, as a group of lesions (linear, pit, and furrow) are the most common enamel defects recorded (Hillson, 2014). My research focuses on linear enamel hypoplasia, and these can be observed both macroscopically and microscopically (Goodman & Rose, 1990; Hillson, 1996, 2014). Enamel hypoplasias are considered non-specific stress indicators (Larsen, 1997); a disruption in the growth of the enamel during a physiologically stressful event, such as famine, malnutrition, or disease. The depth of the "line" caused by linear enamel hypoplasia depends upon the severity of the stressful event, as well as the period of growth that was disrupted. During the growth of the tooth crown, enamel is continuously deposited, and when disturbed does not reform, providing a "clock" that can offer information about the age of the individual during the stressful event (Ensor & Irish, 1995; Larsen, 1997). More accurate results can be achieved by measuring the width of the linear enamel hypoplasia on the scale of a population rather than just one individual (Hubbard et al., 2009).

Linear hypoplastic lesions are typically more common and prominent on incisors and canines as these teeth are more vulnerable to defects than premolars or molars (Goodman & Armelagos, 1985; Skinner & Goodman, 1992; Steckel et al., 2005). The parts of the tooth that are more susceptible to linear enamel hypoplasia are the cervix and middle of the crown (Goodman & Armelagos, 1985; Larsen, 1997).

There are several stressors that have been linked to enamel hypoplasia, ranging from genetic to environmental factors (both neonatal and throughout life), including but not limited to chromosomal anomalies, infectious and metabolic disease, and nutritional deficiencies (Pascoe & Seow, 1994; Hillson et al., 1998; Boldsen, 2007; Masumo et al., 2013; Salanitri & Seow, 2013). The stressors linked to enamel hypoplasia can be organized into three basic categories: systemic metabolic stress, inherited anomalies, and localized trauma (Goodman & Rose, 1991). The exact nature of enamel hypoplasia development is still under investigation, but it is understood that periodic physiological stressors impact the matrix secretion of enamel during dental development between gestation and 4 years of age (Ritzmann et al., 2008; Hillson, 2014), with enamel hypoplasia occurring between the ages of 2 to 4 being most commonly associated with the stress of weaning (Goodman, 1992: 167).

3.3.2 Dental Caries

Carious lesions are a “destruction of the enamel, dentine, and cement resulting from acid production by bacteria in dental plaque” (Hillson, 2014:269), which ultimately leads to a carious lesion, called a cavity colloquially, most commonly in the crown or within the root system. The acid produced by the bacteria originates from the fermentation of food sugars (Moynihan & Petersen, 2004; Hillson, 2004, 2014); this acid dissolves dental tissue, and the lesion itself can manifest as a white or brown opaqueness on the tooth, or large cavities in the teeth (Selwitz et al., 2007). While enamel hypoplasia is the most commonly reported enamel defect, dental caries are the most common general dental lesion reported from archaeological assemblages (Hillson, 2008). Severe, untreated caries can lead to other dental pathologies, such as abscesses and ultimately alveolar remodeling with tooth loss (Selwitz et al., 2007). Unlike the case with enamel hypoplasia, the most vulnerable teeth to dental caries are the premolars and molars, most likely due to their more complex morphology, allowing the bacteria to get stuck and ferment as well as their grinding function (Larsen et al., 1991, Hillson, 2014). There are several factors that contribute to the presence and prevalence of dental caries, with most of them being environmental rather than genetic. Metabolic disorders, such as vitamin D deficiency, and nutritional stress, especially throughout childhood can increase the risk of caries (De Paola et al., 2006). Children are not the only ones at higher risk of dental caries; as individuals age they are exposed to more periodontal disease and alveolar bone resorption, exposing the roots to cariogenic bacteria (Selwitz et al., 2007).

3.3.3 Abscesses

Abscesses, or periapical lesions are bacteria-induced inflammation of the pulp cavity ultimately leading to death of the cavity and a sinus on the surface of the alveolar wall (Ogden, 2008). Abscesses originate from exposure of the pulp cavity, which can occur through general lack of dental hygiene and severe carious lesions, but also through trauma to the tooth, such as breakage or chipping that exposes the pulp cavity to bacteria.

3.3.4 Factors Influencing Tooth Size Dimension

Over the course of human evolution, the size of our teeth has steadily decreased, with modern humans having the smallest teeth of our any members of our family (Scott & Turner, 1997; Hillson & Fitzgerald, 2003). Modern humans show remarkable variation in tooth dimensions, which seems to mostly originate from genetic variation but environmental factors may also play a role (Townsend & Brook, 2008). Some of these non-genetic/environmental factors affecting tooth dimension include prenatal environmental, and the health of the mother during pregnancy, early childhood illness, low birth weight, changes in food preparation, and adoption of specific cooking techniques (Scott & Turner, 1988; Heikkinen et al., 1994, 1997; Stojanowski et al., 2007; Brook, 2009; Fearne & Brook, 1993; Lukacs et al., 1983; Lukacs, 1985; Brace & Hinton, 1981). Variation in tooth dimension can, of course, scale upwards, and research has shown that the amount of protein, lipid, and total calorie intake can increase tooth size, with an established pattern of males having larger dental dimensions than females (Stojanowski et al., 2007).

3.4 Female Buffering

The theory of female buffering is that females are better buffered against the environment (Guatelli-Steinberg & Lukacs, 1999), due to the physiological stress of pregnancy childbirth, lactation, and child rearing. This theory has been tested extensively within the field of biology, through experiments on mice and rhesus macaques being fed low protein diets and recording the effects on the males and females (Stini, 1985; Riopelle, 1990). Hoyenga and Hoyenga (1982) hypothesized that the physiological mechanism of female buffering arose from more severe selection pressures during times of famine or other stress, and therefore evolved to facilitate resiliency. This theory links sex chromosomes with hormones, and overall energy balance. The importance of female buffering to biological anthropology and archaeology is that, if true, it would mean that males would be predicted to retain more stress indicators on their bones than females in a stress population, where culture has little to no influence on the stress.

To explore the effect of female buffering on enamel hypoplasia specifically, Guatelli-Steinberg and Lukacs (1999) surveyed the biological and dental anthropology literature for stressed populations that had an enamel hypoplasia presence, the presence was recorded by sex, and the cultural practices of the population as they relate to stress was given. Due to "stressed population" being an overly broad category, it was broken down into 7, more specific, classifications: (1) neonates of low birth weight, (2) living populations with independent evidence of stress, (3) archaeological samples with independent evidence of stress, (4) slave populations, (5) historical poorhouse samples, (6) low socioeconomic status groups, and (7) indigent individuals or unclaimed bodies. The overall conclusion was that in samples of either direct or indirect evidence of physiological stress, males did not display consistently, and statistically significant greater rates of enamel hypoplasia than females, indicating that the physiological mechanism of female buffering (which may originate from a complex interaction of hormones, sex chromosomes, and energy balance) may not have a strong influence on enamel hypoplasia (Guatelli-Steinberg & Lukacs, 1999).

Chapter 4

RESEARCH AND DATA COLLECTION MATERIALS AND METHODS

4.1 Materials

The Tepe Hissar skeletal assemblage is housed and curated at the University of Pennsylvania Museum of Archaeology and Anthropology (UPM). It is one of the largest collections of human skeletal remains originating from what is modern-day Iran. 1637 skeletons were initially recovered from the Tepe Hissar site in the 1937 excavation led by Erich Schmidt (1897–1964), and currently 397 are housed at UPM, representing all three Hissar periods. For this research, 71 crania and/or mandibles of adult individuals were selected at random on which to conduct dental analysis, with 29 males and 42 females. Specimens were selected from the crania and mandible cabinet for Tepe Hissar at UPM, going from the lowest shelf to the highest. Any specimen that did not have teeth, or was marked as sex indeterminate was not included within the study.

Information on metabolic diseases within the Tepe Hissar population were derived from research on all three Hissar periods by Afshar (2014). The 71 specimens within the Hissar III period metabolic disease evaluation are not the same 71 specimens sampled for this research.

4.2 Methods

Copies of all recording forms used to collect the dentition data from this sample can be found in appendix 1. All recording forms were taken from *Standards for Data Collection from Skeletal Remains* (*Standards*) by Buikstra and Ubelaker (1994). For each individual, a visual recording form was completed for the basic permanent dentition as well as for presence and placement of abscesses on the mandible and maxilla. An inventory recording form was also completed to indicate development, wear, and pathologies such as caries, abscesses and calculus of the permanent dentition. Dental measurements of crown height, mesiodistal diameter, and buccolingual diameter were taken using digital calipers capable of a precision of .01 mm, and were recorded onto the corresponding Buikstra and Ubelaker form. Finally, an enamel defects recording form was completed for each of the individuals examined, noting all enamel defects and opacities of the teeth. The methods outlined by Reid and Dean (2006) were followed to calculate the age of emergence of linear enamel hypoplasia, using crown height measurements. Sex and age had previously been determined within the Tepe Hissar assemblage and those documents were provided to me by the museum.

4.2.1 Methods for Dental Lesion Data Collection

All non-metric dental lesions were macroscopically observed, using a magnifying glass up to 10x magnification in the best available light. Occlusal wear scores were taken for both sides of the maxilla and mandible, using the Smith (1984) system for the incisors, canines, and premolars, and the Scott (1979) system for the molars. Carious lesions were recorded using the system created by Moorrees (1957) and Moore and Corbett (1971). A record was made for all teeth that were present; if a carious lesion was not present on the tooth, then a score of 0 was marked down. Following the procedure in Ubelaker and Buikstra (1994), the presence of calculus was recorded for all teeth present, with a 0 for no calculus, 1 for a small amount, 2 for a moderate amount, and 3 for a large amount of calculus. Hypoplastic features were only recorded for those teeth that presented them; if the tooth did not display any hypoplastic features, then nothing was marked down. The hypoplastic lesions were recorded by type, color, and location, with type and color being scored based on the system outlined in *Standards.* All previous dental data collection systems were recommended by Buikstra and Ubelaker based on their ability to maximize information recovery and minimize intra- and inter-observer error while using standardized methods (47).

4.2.2 Methods for Dental Measurement Data Collection

Mesiodistal and buccolingual diameters were taken for all teeth present on the left side of the maxilla and mandible. If the tooth was absent from the left side, then the antimere was used. For mesiodistal diameters, the measurements were taken using the maximum width of the tooth crown in the mesiodistal plane. For buccolingual diameters, the measurements were taken using the widest diameter of the tooth, perpendicular to the mesiodistal plane. Crown height measurements were taken for all present teeth on the left of the maxilla and mandible. If the tooth was absent from the left side, then the antimere was used. The crown height was determined by measuring from the occlusal surface to the cemento-enamel junction (CEJ) on incisors, canine, and premolars. In molars, the crown height was measured from the top of the mesiobuccal cusp to the CEJ.

4.2.3 Statistical Treatment

To examine sex differences in the various dental lesions evaluated in this research, chi-square tests were conducted at a significance level of 0.05 for linear enamel hypoplasia, dental caries, and abscesses, with the null hypothesis that there was no difference in the sex distribution of these dental lesions.

Chapter 5

RESULTS

5.1 Presence and Prevalence of Dental Lesions

A total of 71 specimens were analyzed for this research, 42 females and 29 males. The total number of teeth analyzed was 1,104, with 673 teeth coming from female specimens and 431 coming from male specimens. The number of females with both the maxilla and mandible present (including partial bone) was 32 out of 42 specimens (76.2%). The number of males with both the maxilla and mandible present (including partial bone) was 17 out of 29 specimens (41.4%).

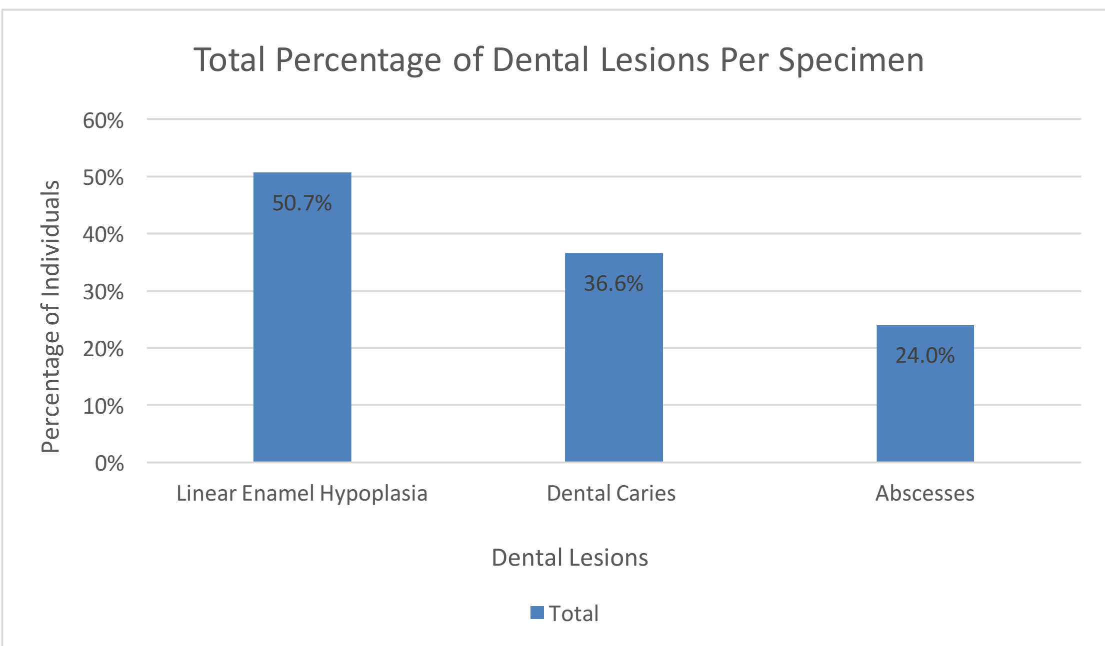


Figure 1: Total Percentage of Dental Lesions

Table 1 Dental Lesions within the Sample

Dental Lesions	*No. specimens affected*	*Population*	*Percentage*
Linear Enamel Hypoplasia	36	71	50.7%
Dental Caries	26	71	36.6%
Abscesses	17	71	24.0%

The presence of the three main dental lesions examined can be found in Figure 1 and Table 1. Considering males and females together, it was found that half of the total sample had at least one linear enamel hypoplasia (50.7%), a little more than a third had at least one carious lesion, and less than a quarter of the total sample had at least one abscess.

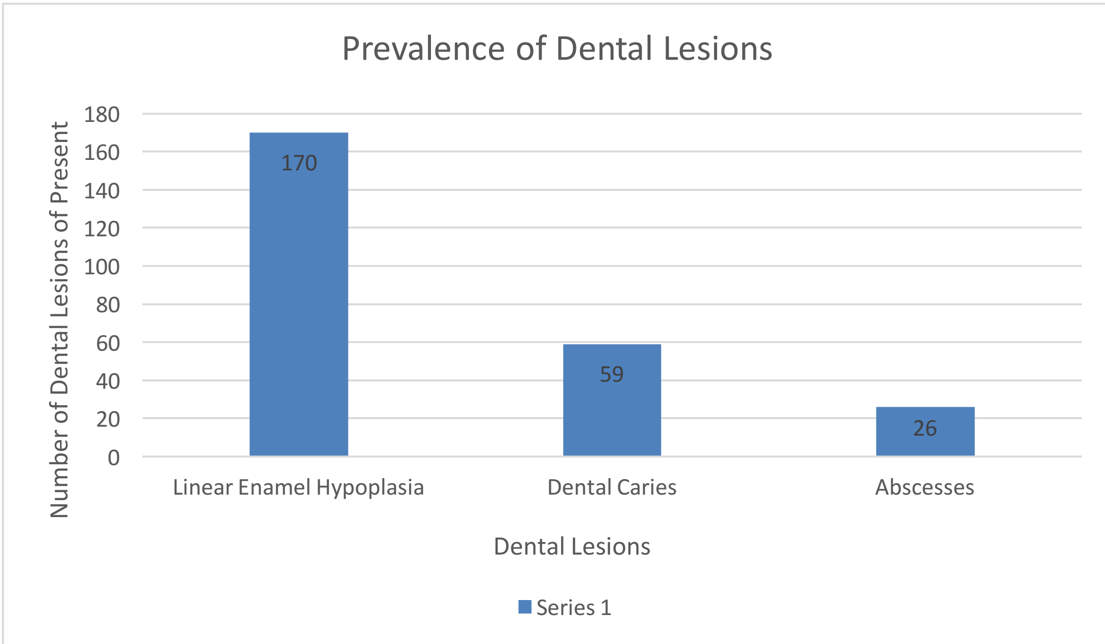


Figure 2: Prevalence of Dental Lesions

As can be seen in Figure 2, the most prevalent dental lesion was linear enamel hypoplasia, with 170 individual lesions within 36 specimens; there was a total of 59 individual carious lesions, and 26 individual abscesses.

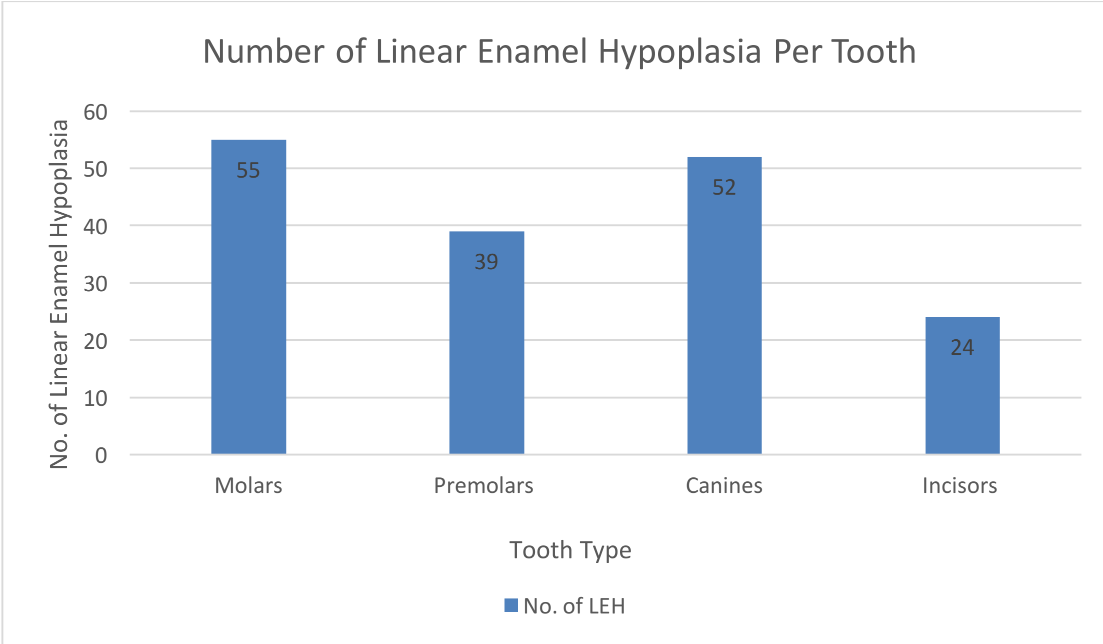


Figure 3: Number of Linear Enamel Hypoplasia Per Tooth

Table 2 Prevalence of Dental Lesions with the Sample

Dental Lesions	*No. of LEH*	*Total LEH*	*Percentage*
Molars	55	170	32.3%
Premolars	39	170	22.9%
Canines	52	170	30.5%
Incisors	24	170	14.1%

Linear enamel hypoplasias are most prevalent on the molars and canines, which is consistent with the established pattern of LEH explained in chapter 3, section

3.1. The less vulnerable teeth, the premolars and incisors, have a predictably lower rate of linear enamel hypoplasia (Fig. 3).

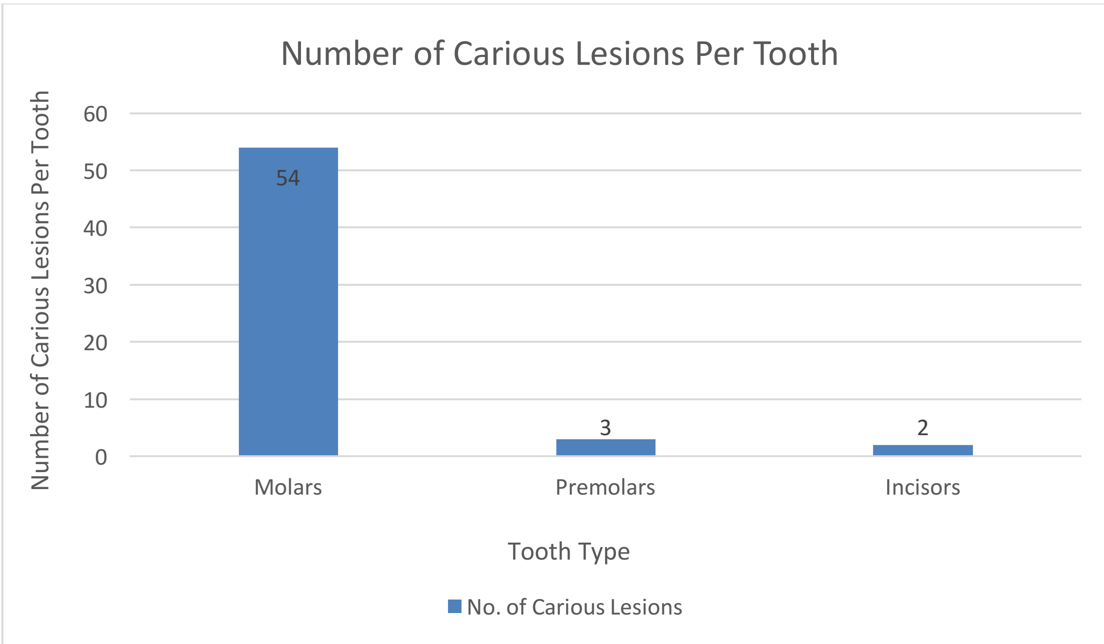


Figure 4: Number of Carious Lesions Per Tooth

The distribution of carious lesions also closely follows the established pattern, with the majority of CAR on the molars, with only 3 present on premolars and 2 present on incisors (Fig. 4). The 2 carious lesions on incisors are from the same specimen. There were no carious lesions present on the canines.

5.2 Sex Differences in the Dental Lesions

Females have a higher rate than males for all three of the main dental lesions examined, but the only statistically significant sex difference was found in linear enamel hypoplasia ($X^2 = 7.5884$, $p = 0.005874$) (Figure 5 and Table 3).

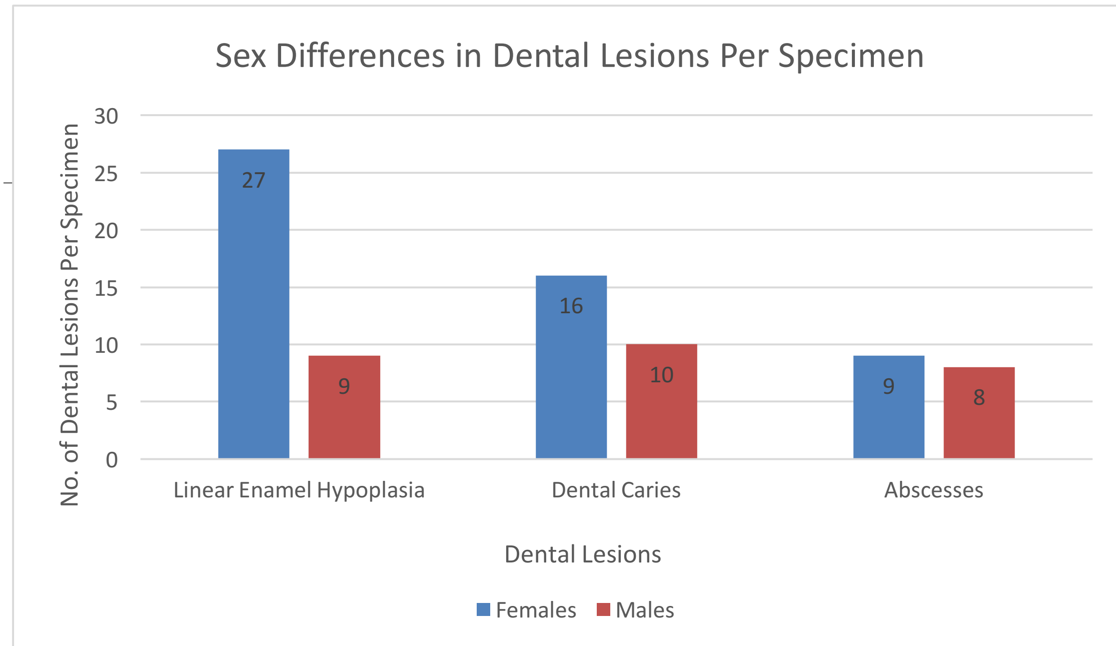


Figure 5: Sex Differences in Dental Lesions Per Specimen

Table 3: Dental Pathology Profile by Sex

Disease	*Female*		*Male*		*Total*		*Comparison*	
	Affected/Observed	%	Aff./Ob.	%	Aff./Ob.	%	X^2	*P*
LEH	27/42	64.2%	9/29	31%	36/71	50.7%	7.588	0.0058
CAR	16/42	38.1%	10/29	34.5%	26/71	36.6%	0.096	0.7561
AB	9/42	21.4%	8/29	27.6%	17/71	23.9%	0.357	0.5500

Table 4: Sex Differences in Prevalence of Dental Pathology

Dental Lesions	*Female*		*Male*		*Total*	
	No. of Lesion/Total	%	No. of Lesion/Total	%	No. of Lesions/Total	%
Dental Caries	40/673	6%	19/431	4.4%	59/1104	5.3%
Abscesses	13/673	1.93%	13/431	3%	26/1104	2.4%
LEH	126/673	18.7%	44/431	10.2%	170/1104	15.4%

Females had a higher prevalence of carious lesions and linear enamel hypoplasia than the males, while males had a slightly higher prevalence of abscesses (Table 4).

5.3 Age of Emergence for Linear Enamel Hypoplasia

The age of emergence for linear enamel hypoplasia was calculated using crown height and following the procedure created by Reid and Dean (2006). The results show that for the canines, and third and second molars, the age of emergence for the linear enamel hypoplasia was not statistically different between the sexes.

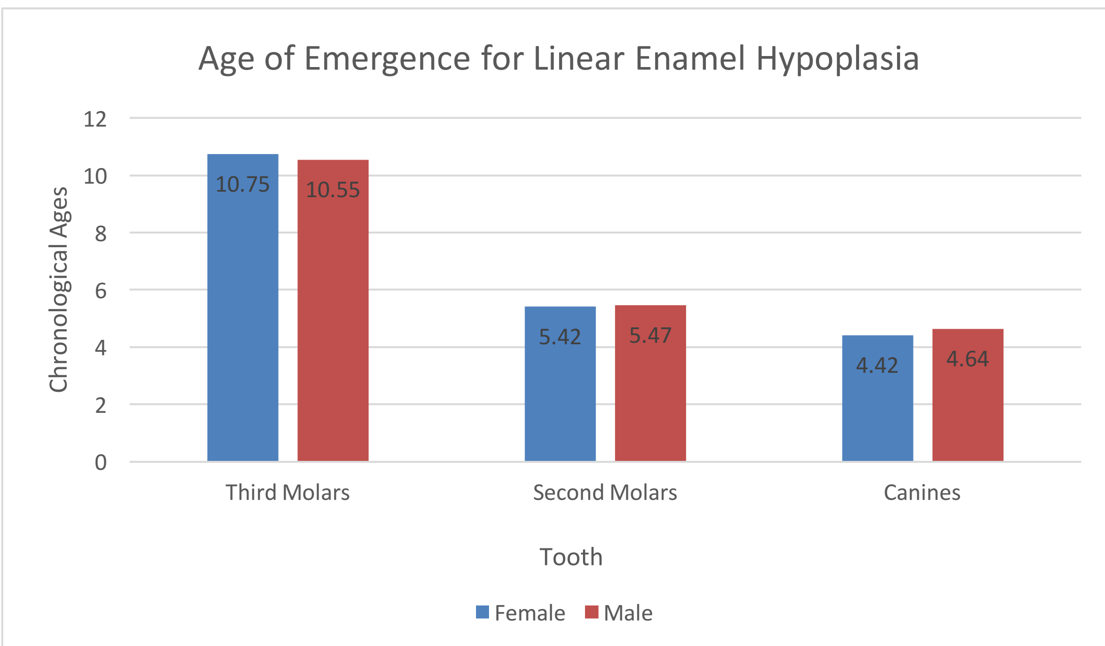


Figure 6: Age of Emergence for Linear Enamel Hypoplasia

5.4 Summary of Data by Sex

5.4.1 Females

Table 5: Presence and Prevalence for Females in Dental Pathology

	Presence		*Prevalence*	
	Affected/Observed	%	Observed/Present	%
LEH	27/42	64.2%	126/673	18.7%
CAR	16/42	38.1%	40/673	6%
AB	9/42	21.4%	13/673	1.3%

Table 6: Age of Emergence in of LEH in Females

Tooth	*Age of Emergence*
Third Molars	10.75
Second Molars	5.42
Canines	4.42

The presence and prevalence of the three main dental lesions for females are outlined in Table. Females were mostly affected by linear enamel hypoplasia, with 64.2% of the sample having at least one LEH, and a prevalence of 10.2%. Females were secondarily affected by carious lesions, with 38.1% of the sampled females having at least one, with a frequency of 18.7% for dental caries, recorded by tooth, socket, and roots belonging to a female specimen (Table 6). There was only a difference of 1 abscess between males and females, with males having a slightly higher frequency than females.

5.4.2 Males

Table 7: Presence and Prevalence of Dental Pathology in Males

	Presence		*Prevalence*	
	Affected/Observed	%	Affected/Observed	%
LEH	9/29	31%	44/431	10.2%
CAR	10/29	34.5%	19/431	4.4%
AB	8/29	27.6%	13/431	3%

Table 8: Age of Emergence for LEH in Males

Tooth	*Age of Emergence*
Third Molars	10.55
Second Molars	5.47
Canines	4.64

Unlike their female counterparts, males were most affected by carious lesions, with 34.5% of the male sample having at least one carious lesion, (Table 7). The frequency of carious lesions for males was 4.4%. The age of emergence of LEH for males is very like those ages for females, with no statistical significance.

Chapter 6

DISCUSSION

6.1 Dental Pathology Profile by Period and Sex

Afshar (2014) collected data on both dental pathology profiles and metabolic disease in the Tepe Hissar assemblage separately for the three Hissar periods. In this section of the discussion, Afshar's dental pathology profiles will be combined with my research to gain a better understanding of the dental health of each period. It should be noted that Afshar's samples are the not the same as those taken within this research; Afshar's research sampled 28 specimens from Hissar I, 53 specimens from Hissar II, and 287 specimens from Hissar III (Table 9).

Table 9: Sex Distribution by Period (Afshar's data)

Period	*Sex Distribution*	*No.*	*%*
Hissar I	Male	14	50%
	Female	10	35.7%
Hissar II	Male	17	31.1%
	Female	31	58.5%
	Indeterminate	5	9.4%
Hissar III	Male	17	32.1%
	Female	31	58.5%
	Indeterminate	5	9.4%

6.1.1 Hissar I

Afshar found that within Hissar I, males had higher rates of periapical lesions (ABC), carious lesions (CAR), and attrition (ATR) than females. Females had higher rates of anti-mortem tooth loss (AMTL), calculus (CAL), and enamel hypoplasias (DEH). These differences were not statistically significant.

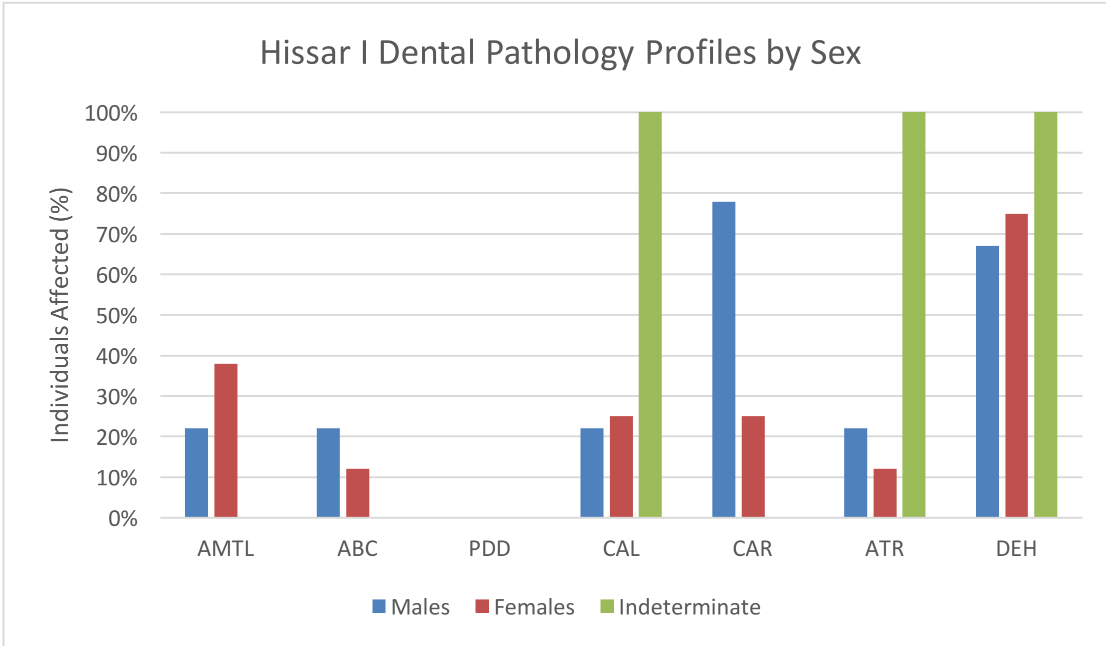


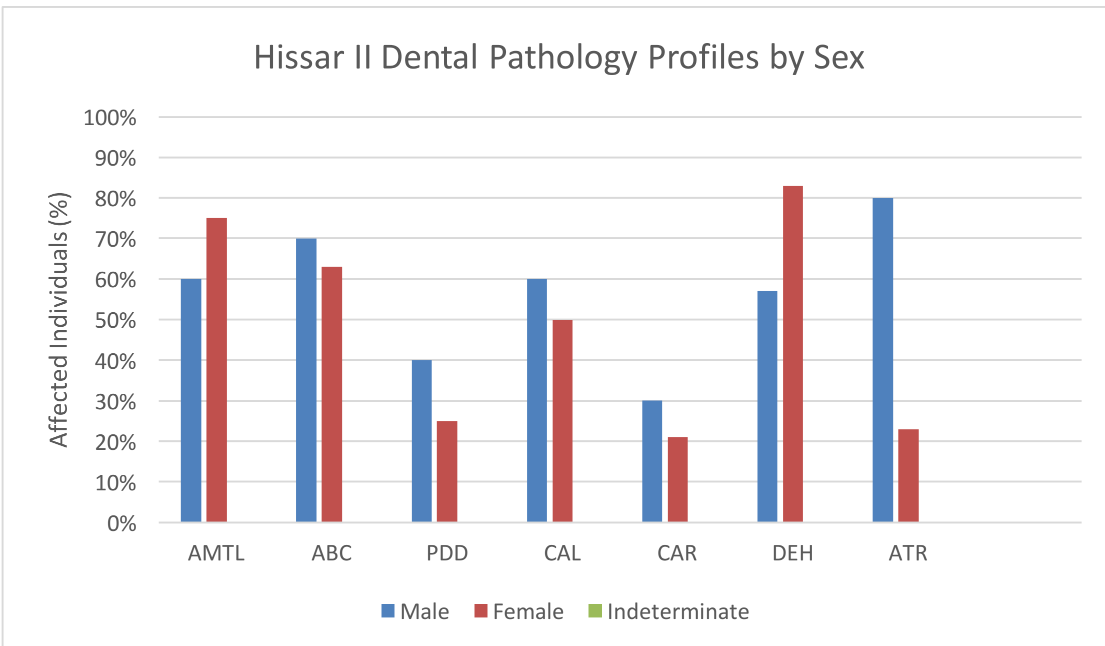
Figure 7: Hissar I Dental Pathology Profiles by Sex (Recreated from Afshar 2014)

Table 10: Hissar I Dental Pathology by Sex (Recreated from Afshar 2014)

Disease	*Male*		*Female*		*Indeterminate*		*Total*		*Comparison*	
	Aff./Ob.	%	Aff./Ob.	%	Aff./Ob.	%	Aff./Ob.	%	X^2	P
AMTL	2/9	22%	3/8	38%	0/1	0%	5/18	28%	0.900	0.638
ABC	2/9	22%	1/8	12%	0/1	0%	3/18	175	0.500	0.779
PDD	0/9	0%	0/8	0%	0/1	0%	0/18	0%	-	-
CAL	2/9	22%	2/8	25%	1/1	100%	5/18	28%	5.082	0.279
CAR	7/9	78%	2/8	25%	0/1	05	9/18	505	5.778	0.056
DEH	6/9	67%	6/8	75%	1/1	100%	13/18	72%	0.554	0.758
ATR	2/9	22%	1/8	12%	1/1	100%	4/18	22%	3.938	0.140

6.1.2 Hissar II

For Hissar II, a total of 27 out of the 53 specimens had mandible and maxillary bones preserved well enough to evaluate, with 10 males, 16 females, and 1 of unknown sex. The males showed a higher percentage of periodontal disease, periapical lesions, calculus, carious lesions, and attrition than females. Females, similar to Hissar I, displayed a higher percentage of anti-mortem tooth loss, and enamel hypoplasias. Other than attrition ($X^2 = 8.260$, $P = 0.016$), none of these differences were of



statistical significance.

Figure 8: Hissar II Dental Pathology Profiles by Sex (Recreated from Afshar 2014

Table 11: Hissar II: Dental Pathology Profiles by Sex (Recreated from Afshar 2014)

Disease	*Male*		*Female*		*Indeterminate*		*Total*		*Comparison*	
	Aff./Ob.	%	Aff./Ob.	%	Aff./Ob.	%	Aff./Ob.	%	X^2	*P*
AMTL	6/10	60%	12/16	75%	0/1	0%	18/27	67%	2.700	0.2559
ABC	7/10	70%	10/16	63%	0/1	0%	17/27	63%	1.914	0.384
PDD	4/10	40%	4/16	25%	0/1	0%	8/27	67%	1.101	0.577
CAL	6/10	60%	7/14	50%	0/1	0%	13/25	52%	2.708	0.608
CAR	3/10	30%	3/14	21%	0/1	0%	6/25	24%	0.564	0.754
DEH	4/7	57%	10/12	83%	0/1	0%	14/20	70%	3.900	0.142
ATR	8/10	80%	3/13	23%	0/1	0%	11/24	46%	8.260	0.016

6.1.3 Hissar III

For Hissar III, Afshar (2014) analyzed a total of 169 individuals had mandibles and maxillae preserved well enough to evaluate, with 95 males, 68 females, and 6 indeterminate. During this period, almost all of the dental diseases were seen at a higher frequency in males (anti-mortem tooth loss, periapical lesions, periodontal disease, carious lesions, and attrition). These differences were only significant in anti-mortem tooth loss ($X^2 = 6.66$, $P = 0.024$). Females had a higher rate of enamel hypoplasia, and calculus than males, but males had a higher prevalence rate of enamel hypoplasias by tooth count. None of these differences were statistically significant.

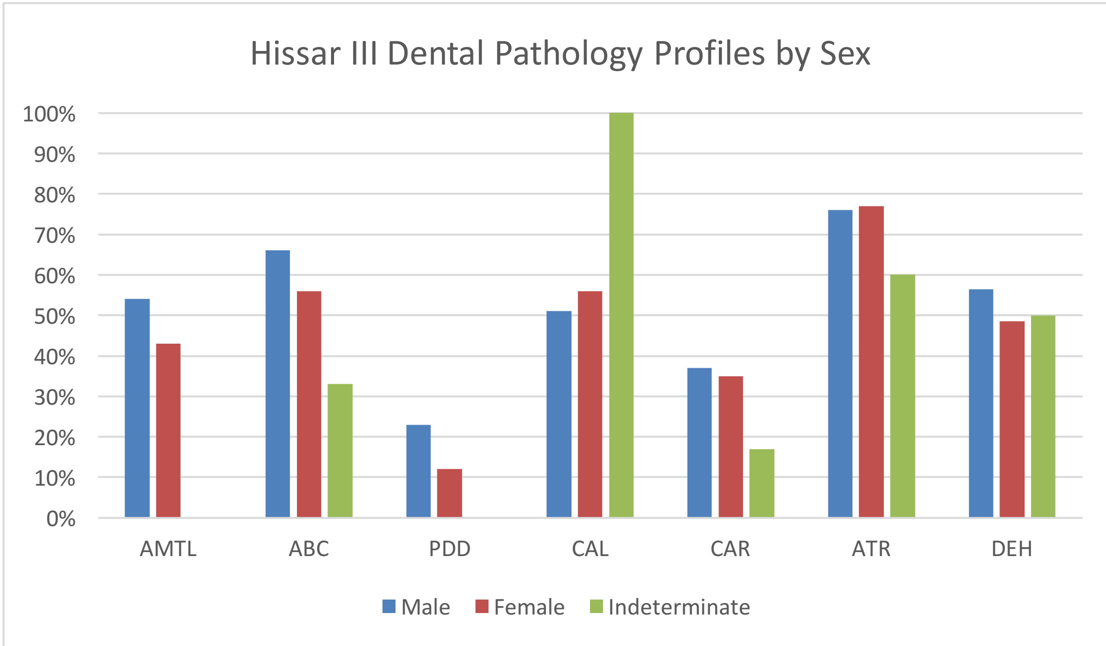


Figure 9: Hissar III Dental Pathology Profiles by Sex (Recreated from Afshar 2014).

Table 12: Hissar III Dental Pathology by Sex (Recreated from Afshar 2014)

Disease	*Male*		*Female*		*Indeterminate*		*Total*		*Comparison*	
	Aff./Ob.	%	Aff./Ob.	%	Aff./Ob.	%	Aff./Ob.	%	X^2	P
AMTL	51/95	54%	29/68	43%	0/6	0%	80/169	47%	7.528	0.023
ABC	63/95	66%	38/68	56%	2/6	33%	102/169	60%	3.805	0.149
PDD	22/95	23%	8/68	12%	0/6	0%	30/169	18%	4.866	0.088
CAL	47/92	51%	36/66	56%	6/6	100%	89/164	54%	6.588	0.361
CAR	34/92	51%	36/66	56%	1/6	17%	57/163	35%	1.027	0.598
DEH	54/71	76%	40/52	77%	3/5	60%	97/128	76%	0.718	0.698
ATR	52/92	56.5%	32/66	48.5%	3/6	50%	87/164	53%	1.020	0.601

Across the three periods, females have higher presence and frequency of enamel hypoplasia than males, with the exception of period III, when males had a higher frequency of the lesion. Afshar's (2014) results correspond to the results found within this research, of females having a higher presence and frequency of linear enamel hypoplasia than males (statistically significant). The results of this research found a higher rate of carious lesions in females than in males (not statistically significant), but Afshar found higher rates and frequencies of dental caries in males for Hissar I and II. Females only had a slightly higher rate of carious lesions in Hissar III.

Table 13: Comparison of DEH, CAR, and ABC by Sex and Period (Recreated from Afshar's data)

Period	*Disease*	*Male*		*Female*	
Hissar I		Aff./Ob.	%	Aff./Ob.	%
	DEH	6/9	67%	6/8	75%
	CAR	7/9	78%	2/8	25%
	ABC	2/9	22%	1/8	12%
Hissar II					
	DEH	4/7	57%	10/12	83%
	CAR	3/10	30%	3/14	21%
	ABC	7/10	70%	10/16	63%
Hissar III					
	DEH	54/71	76%	40/52	77%
	CAR	34/92	51%	36/66	56%
	ABC	63/95	66%	38/68	56%

6.1.4 Summary of the Dental Pathology Profile by Period and Sex

Any conclusions drawn from this data are vulnerable to bias from various factors, ranging from the samples themselves (poor preservation, type of burial, migration of the population, etc.) to the excavation and handling of the samples (incompletely recovered remains, processing of the remains, inaccurate skeletal aging and sexing techniques) (Henderson, 1987; Anthony, 1990; Wood et al., 1992; Norman et al., 2005).

Overall, the healthiest time of the three periods analyzed by Afshar (2014) was Hissar I, particularly in terms of periodontal disease and periapical lesions, with 0% of the inhabitants of Hissar I showing evidence of periodontal disease, and only 17% of this period having at least one periapical lesion, or abscess. Periodontal disease seems to have increased sharply in Hissar II, and then fallen in Hissar III. Males suffered more from periodontal disease in Hissar II and Hissar III, but the differences between the sexes were small and not statistically significant. The decrease in periodontal disease in Hissar III may be indicative of a change in subsistence pattern to foods less mechanically demanding. This correlates with the archaeological evidence that many changes in housing styles, craft specialization and societal stratification took place during Hissar III. Unlike Hissar I, the rates of periapical lesions are high for males and females in Hissar II and III. As mentioned in chapter 3, section 3.3, periapical lesions can originate from untreated and severe dental caries, crown or root fractures or breakage, or even dental attrition. The higher rates of periapical lesions in the last two periods of Tepe Hissar are indicative of a decline in overall dental health for both males and females.

Stress, and a change in subsistence pattern due to the violent cultural transitions taking place during periods II and III could be the reason for the decline in dental health. There are slight increases in overall dental heath in Hissar III from Hissar II for both males and females, but as mentioned previously, this can be attributed to the changes taking place in Hissar III. Also, the decline in dental health in Hissar II and III, along with the minor, statistically insignificant differences between sexes indicates that, unlike in Hissar I, the males and females in Hissar II and III had similar diets, and were sourcing their diets from similar resources. This could be due to the turmoil of the cultural transition restricting access to certain foods, as well as causing stress which in turn worsened the oral (and overall) health of both sexes. These results from Afshar (2014) are corroborated by the results obtained from this research, such as the minor differences between the sexes in abscesses and carious lesions.

Males in Hissar I had the highest rate of carious lesions for either sex in any period. Evidence suggests that Hissar I, much more than the other periods, had a mixed diet mostly dependent upon wheat and barley, with a lack of the diversity of crops shown in Hissar II and III (Costantini & Dyson, 1990; Afshar, 2014). For Hissar I, the caries rates for males are more consistent with that found in an agricultural society, while the caries rates for females is more consistent with a hunting and gathering society; this is a contrary pattern to what is typically seen, with females having a higher carious lesion rate to their male counterparts (Larsen et al., 1991; Temple & Larsen, 2007). It may be that males may have had access to more carbohydrate rich foods, such as honey and/or fruits, while the females had more access to protein rich foods, such as fish or small game.

For the first two periods of Tepe Hissar, females displayed a higher rate of ante-mortem tooth loss compared to males. This difference was statistically insignificant, however. During period III, this pattern shifted, and males had a statistically significant difference in ante-mortem tooth loss in comparison to females. Ante-mortem tooth loss may originate from a variety of factors, such as food preparation methods and consistency, as well as nutritional deficiency diseases, but traumatic injury can also contribute to the frequency of AMTL (Lukacs, 2006). The frequency of ante-mortem tooth loss was highest for males in Hissar III. This high frequency suggests that the violence occurring at the time may have led to more traumatic injuries in males, and therefore the shifting of a pattern, and a statistically significant higher rate of AMTL in males compared to females in Hissar III.

When it comes to enamel hypoplasias, the results obtained from this research showed an overall statistically significant difference in the rate of LEH between males and females. The difference was substantial, with 64.2% of females displaying at least one LEH, while only 31% of males displayed at least one LEH. The results obtained by Afshar (2014) contrast with this finding; she found no statistical significance found in DEH from any period of Tepe Hissar, and while DEH rates were high among both males and females, the differences between them were minor. While the differences in DEH rates in Afshar’s samples may not be statistically significant, they show that females displayed higher rates of DEH than males in each of the three periods, with no shift or change in that pattern. The consistency of this pattern, combined with my finding of statistical significance assumes that the experience of DEH, and in particular, LEH, was a disproportionally female one for the Tepe Hissar population.

In conclusion, it is assumed that before the cultural transitions, Tepe Hissar had relative stability and good dental health, with the males suffering from more carious lesions then the females, but with an absence or lack of periodontal disease and periapical lesions in both sexes. The violence and destruction noted in the archaeological record for Hissar periods II and III impacted these established patterns in Hissar I; some of these shifts affected males and females in relatively similar ways, while other did not, giving us a glimpse into the culture of the Tepe Hissar site. For example, in periods II and III, females began to match males in carious lesion rates, indicating both sexes were likely sourcing their diet from the same resources instead of there being a distinct dichotomy as is hypothesized for Hissar I. This change could be the result of a restriction to or destruction of resources as the cultural transitions took place, or of a change in subsistence pattern to a more similar diet between the sexes, or some amalgam of the two.

A pattern shift that specifically affected males would be the statistically significant change in AMTL rates and frequencies in males during Hissar III. This change from females having higher rates of AMTL (statistically insignificant) to males during this time could be attributable to the violence occurring at the time, as indicated archaeological evidence of an increase in mass burials, and the Burned Building (discussed in Chapter 2). This result illustrates the difference in life experiences between male and female inhabitants of Tepe Hissar. Similarly, the consistent pattern of higher DEH in females, a pattern that withstood the violent cultural transitions, paired with the results obtained from this research of statistically significant higher rates of LEH in females, provides insight into the life experiences of females at Tepe Hissar.

6.2 Afshar (2014) Metabolic Disease Profile

Overall, Afshar (2014) found that there was a slight decline in health over the three Tepe Hissar periods, and a slight increase in metabolic disease. These statistically insignificant changes are not enough to support the hypothesis that the violent cultural transitions occurring during periods II and III had an impact on overall health.

Osteoporosis is generally found to be more prevalent in females than in males within both archaeological and living populations (Grauer, 1998; Larsen, 1997) However, Afshar (2014), along with other paleopathological studies of the Tepe Hissar assemblage (Ravin-Haque, 1992; Gürsan-Salzmann, 2016), found that osteoporosis in females did not have a statistically significant higher rate than that of males. Therefore, it is likely that in terms of workload and physical labor, the males and females of the three periods of Tepe Hissar had similar tasks, and split the work evenly.

Chapter 7

CONCLUSIONS

7.1 Hypothesis

Males and females were treated differently through cultural practices, leading to a greater biological stress in females, the consequences of those differences would show up on the teeth. The three main dental pathologies chosen to measure this are linear enamel hypoplasia, dental caries, and abscesses. The most violent cultural shifts occurred in Hissar III, and the population likely experienced the most stress during this period, therefore LEH, CAR, and AB will be greater overall, and likely greater in females.

My data, showing statistically significant linear enamel hypoplasia rates within females as compared to males, along with a similar finding in Hemphill (2008), and a similar, non-statistically significant, pattern found within Afshar (2014), supports the hypothesis that females did experience a higher frequency of linear enamel hypoplasia than males. There was no statistically significant difference between the sexes for carious lesions or for abscesses, not supporting the hypothesis that these two dental lesions would also be statistically higher in females. This finding is substantiated by similar findings by Hemphill (2008), and Afshar (2014). According to Afshar (2014)'s data, the rates of linear enamel hypoplasia remained high in females throughout the three periods. Period II had the highest rate of enamel hypoplasia in females (83%), not period III. Similarly, the periapical lesions were highest for females in period II

(63%), not period III (56%). In contrast, carious lesions were at their highest for females in period III (56%).

The metabolic disease rates of the females as compared to the males varied only minimally throughout the three periods, and not in any statistically significant way. Therefore, the hypothesis that the role of females within Tepe Hissar culture led them to have heavier workloads, and therefore higher rates of osteoporosis and other degenerative diseases was not supported.

7.2 Research Questions

Table 14: Research Questions and Answers

Research Questions	Answers
Is there a statistically significant difference in LEH, CAR, and/or AB between males and females?	For linear enamel hypoplasia, there is a statistically significant difference. There is not for carious lesions, or abscesses.
Is there a higher presence and/or frequency of LEH, CAR, and/or AB within the Hissar III period?	Yes and No; while dental lesions, including LEH, CAR, and AB increased through time, the highest rates did not occur within this period.
If so, which sex has the higher presence and/or frequency of LEH, CAR, and/or AB?	While the rates of dental lesions overall increases throughout time, neither sex had a statistically higher rate of dental lesions than the other.
Is there a statistically significant difference within the skeletal lesions of the males and females that denote workload or lifestyle	No; the minor differences between the sexes for metabolic and degenerative diseases were not statistically significant, denoting that most likely there was little difference in workload and lifestyle between the sexes.

7.3 Concluding Remarks

The statistically significant difference in rates between males and females for linear enamel hypoplasia along with the age similarity in linear enamel hypoplasia emergence, suggests that childhood age (gestation to 11 years of age) females were experiencing more of, and/or a more severe form of, some stressor at the same age as males. The female buffering theory may explain the minor, statistically insignificant differences between the sexes in carious and periapical lesions. The female buffering theory posits that females are better buffered against physiological stress (Stini, 1969, 1972, 1975, 1978, 1985). This evolution of better buffered females evolved as an adaptation to the stress of reproductive functions, such as pregnancy, lactation, and overall childrearing (Guatelli-Steinberg & Lukacs, 1999).

If females were experiencing more of a particular stressor, or a more severe form of a particular stress than males at around the same age, as suggested by my results, it would stand to reason that they were possibly also experiencing more stressors related to carious and periapical lesions. However, the females were buffered against these stressors more so than the one(s) causing linear enamel hypoplasia, for reasons unknown, and therefore their lesion rates are similar to those of males.

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Appendix A

Recording Forms

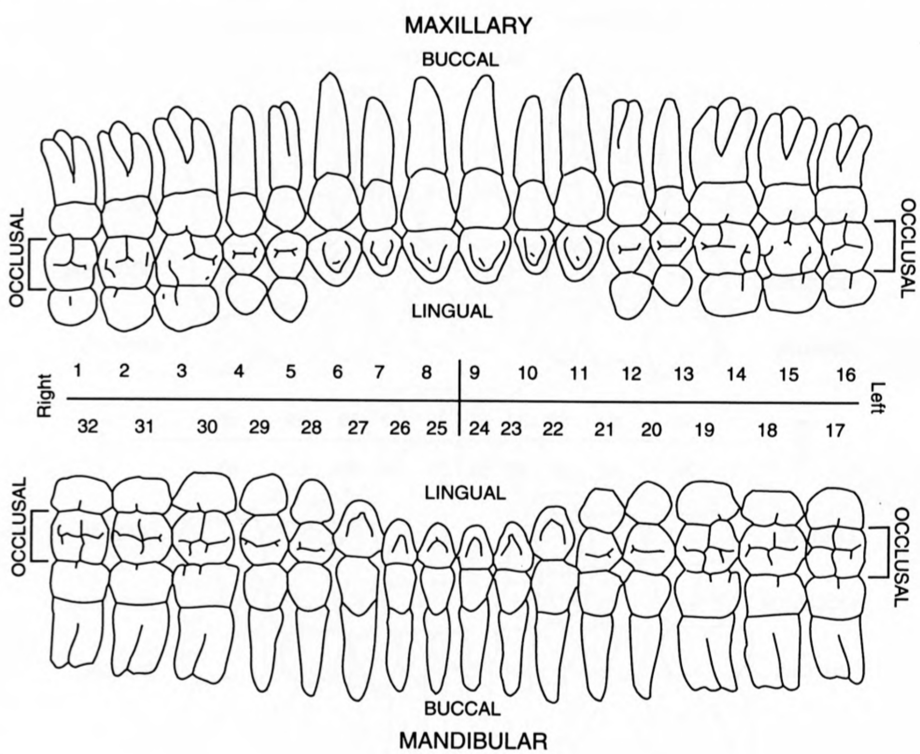
DENTAL INVENTORY
VISUAL RECORDING FORM: PERMANENT DENTITION

Site Name/Number ____________________/____________________ Observer ____________________

Feature/Burial Number ____________________/____________________ Date ____________________

Burial/Skeleton Number ____________________/____________________

Present Location of Collection ____



CHAPTER 5: *Attachment 14a*

DENTAL INVENTORY RECORDING FORM

DEVELOPMENT. WEAR. AND PATHOLOGY: PERMANENT TEETH

Site Name/Number ______________________/____________________ Observer ____________________

Feature/Burial Number ____________________/____________________ Date ____________________

Burial/Skeleton Number ____________________/____________________

Present Location of Collection ____

Tooth presence and development: code 1-8. For teeth entered as "1" (present, but not in occlusion), record stage of crown/root formation under "Development." **Occlusal surface wear:** use left teeth, following Smith (1984) for anterior teeth (code 1-8) and Scott (1979) for molars (code 0-10). If marked asymmetry is present, record both sides. Record each molar quadrant separate in the spaces provided (+) and the total for all four quadrants under "Total." **Caries:** code each carious lesion separately (1-7); **Abscesses:** code location (1-2). **Calculus:** code 0-3, 9. Note surface affected (buccal/labial or lingual).

		Tooth Presence	Development	Wear /Total	Caries	Abscess	Calculus/Affected
Maxillary Right	1 M^3						
	2 M^2						
	3 M^1						
	4 P^2						
	5 P^1						
	6 C						
	7 I^2						
	8 I^1						
Maxillary Left	9 I^1						
	10 1^2						
	11 C						
	12 P^1						
	13 P^2						
	14 M^1						
	15 M^2						
	16 M^3						

Series/Burial/Skeleton________________

Observer/Date____________________

		Tooth Presence	Development	Wear /Total	Caries	Abscess	Calculus/Affected
Mandibular Left	17 M_3	___	___	___ ___	___ ___ ___	___	___ ______
	18 M_2	___	___	___ ___	___ ___ ___	___	___ ______
	19 M_1	___	___	___ ___	___ ___ ___	___	___ ______
	20 P_2	___	___	___ ___	___ ___ ___	___	___ ______
	21 P_1	___	___	___ ___	___ ___ ___	___	___ ______
	22 C	___	___	___ ___	___ ___ ___	___	___ ______
	23 I_2	___	___	___ ___	___ ___ ___	___	___ ______
	24 I_1	___	___	___ ___	___ ___ ___	___	___ ______
Mandibular Right	25 I_1	___	___	___ ___	___ ___ ___	___	___ ______
	26 I_2	___	___	___ ___	___ ___ ___	___	___ ______
	27 C	___	___	___ ___	___ ___ ___	___	___ ______
	28 P_1	___	___	___ ___	___ ___ ___	___	___ ______
	29 P_2	___	___	___ ___	___ ___ ___	___	___ ______
	30 M_1	___	___	___ ___	___ ___ ___	___	___ ______
	31 M_2	___	___	___ ___	___ ___ ___	___	___ ______
	32 M_3	___	___	___ ___	___ ___ ___	___	___ ______

Estimated dental age (juveniles only)______________

Supernumerary Teeth:	Position between teeth	Location (1 - 4)	Position between teeth	Location (1 - 4)	Position between teeth	Location (1 - 4)
	____/____	_____	____/____	_____	____/____	_____
	____/____	_____	____/____	_____	____/____	_____

Comments:

____

____

____

____

____

____

Attachment 16: CHAPTER 5

SUPERNUMERARY TEETH AND ABSCESSES
VISUAL RECORDING FORM: MAXILLARY DENTITION

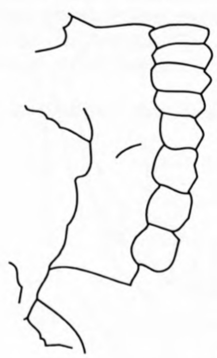
Site Name/Number ____________________/__________________ Observer __________________

Feature/Burial Number ____________________/__________________ Date __________________

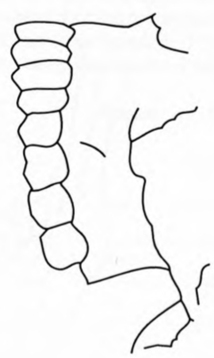
Burial/Skeleton Number ____________________/__________________

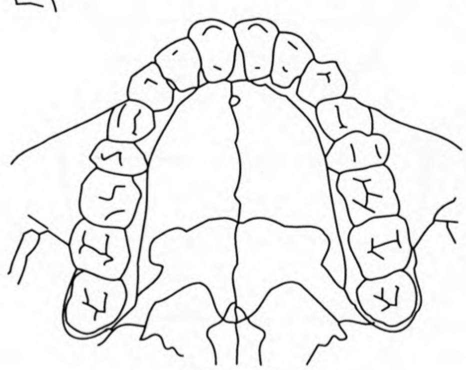
Present Location of Collection ____

Right Buccal View



Left Buccal View





Palatal View

SUPERNUMERARY TEETH AND ABSCESSES VISUAL RECORDING FORM: MANDIBULAR DENTITION

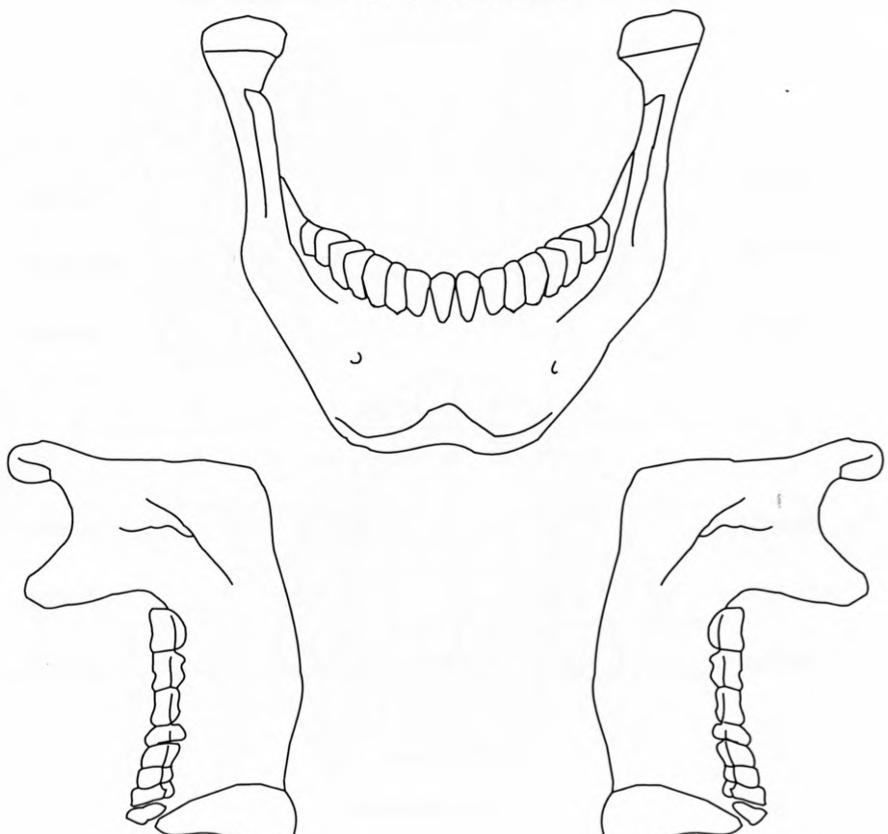
Site Name/Number ______________ / ______________ Observer ______________

Feature/Burial Number ______________ / ______________ Date ______________

Burial/Skeleton Number ______________ / ______________

Present Location of Collection ______________________________

Frontal (Labial)/Buccal View



Right Lingual View

Left Lingual View

Attachment 15b: CHAPTER 5

DENTAL MEASUREMENTS AND MORPHOLOGY RECORDING FORM

Site Name/Number ______________/______________ Observer ______________

Feature/Burial Number ______________/______________ Date ______________

Burial/Skeleton Number ______________/______________

Present Location of Collection ______________________________

Dental Measurements

Record left side of arcade only; substitute antimere when left not observable.

Maxilla

Tooth	I^1	I^2	C	PM^1	PM^2	M^1	M^2	M^3
Mesiodistal diameter								
Buccolingual diameter								
Crown height								

Mandible

Tooth	M_3	M_2	M_1	PM_2	PM_1	C	I_2	I_1
Mesiodistal diameter								
Buccolingual diameter								
Crown height								

ENAMEL DEFECTS (HYPOPLASIAS AND OPACITIES) RECORDING FORM: DECIDUOUS TEETH

Site Name/Number ____________________/____________________ Observer ________________

Feature/Burial Number ____________________/____________________ Date ________________

Burial/Skeleton Number ____________________/____________________

Present Location of Collection ____

Type: code 0-7 or 9.
Location: measure distance from the CEJ to the most occlusal portion of defect.
Color: code 1-4 for hypocalfications (type 6 or 7) only.

Maxilla, Right

Tooth	m^2			m^1			c			i^2			i^1		
Defect	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Type															
Location															
Color															

Maxilla, Left

Tooth	i^1			i^2			c			m^1			m^2		
Defect	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Type															
Location															
Color															

Mandible, Left

Tooth	m_2			m_1			c			i_2			i_1		
Defect	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Type															
Location															
Color															

Mandible, Right

Tooth	i_1			i_2			c			m_1			m_2		
Defect	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Type															
Location															
Color															

Attachment 18b: CHAPTER 5