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Dental Disease at Ancient Mendes (Tell er-Rubᶜa), Egypt

Courtney McConnan Borstad* and Nancy C. Lovell**

Abstract: Extensive excavations at Tell er-Rubᶜa (ancient Mendes) have documented aspects of the city's political and cultic significance and its development over several millennia, but much less is known about the inhabitants of the city themselves. This paper presents an analysis of dental health as exhibited by human remains recovered from the site by the Institute of Fine Arts at New York University and the University of Alberta. Permanent teeth from 69 individuals were examined for evidence of infectious dental disease (caries and periapical abscesses), calculus, antemortem tooth loss, and the severity of occlusal tooth wear.

One-third of the individuals displayed evidence of carious lesions (cavities), although most affected individuals had only one affected tooth. More females had carious lesions than did males, a difference that is not statistically significant. Seventeen per cent of those individuals with associated jawbone fragments show evidence of periapical abscess formation (a not uncommon sequel to a carious lesion), although no sex difference was observed. The frequencies of caries and abscesses in this sample are consistent with the consumption of a high carbohydrate diet. More than two-thirds of the adults are affected by supra-gingival calculus, which is sometimes referred to as tartar. In this sample, calculus is correlated with alveolar resorption, the latter condition a bony response to periodontitis. Both abscessing and alveolar resorption are implicated in the antemortem loss of teeth. Tooth wear is pronounced, with sex differences between middle-aged males and females identified.

Despite difficulties of interpretation caused by small sample sizes and preservation issues, the results of this analysis are consistent with other published reports of dental palaeopathology among ancient Egyptians. In essence, molar crown wear, particularly among older individuals, tends to be pronounced and the pattern of dental disease is consistent with a diet high in carbohydrates that likely included bread and naturally sweet and sticky foods such as dried fruits and honey.

Résumé: Les fouilles menées à Tell er-Rubca (mieux connue sous le nom de Mendes) ont déjà jeté une lumière sur l'importance politique et culturelle de la ville et son développement à travers plusieurs millénaires, mais nous sommes généralement moins bien renseignés sur la vie quotidienne des habitants de la ville. Cet article vise en partie à combler cette lacune, en proposant une étude sur la santé dentaire de personnes dont les restes humains ont été retrouvés sur le site et analysés par l'Institut des beaux-arts de l'Université de New York University et l'Université d'Alberta. Les dents de 69 personnes ont été examinées pour des signes de maladies infectieuses (caries et les abcès périapicaux), de calcul dentaire, de pertes de dents ante mortem, et de malocclusion dentaire.

Un tiers des personnes montraient des signes de lésions carieuses, bien que la plupart des personnes touchées avaient seulement une dent affectée. Plus de femmes présentaient des lésions carieuses que d'hommes, une différence qui n'est pas statistiquement significative. Dix-sept pour cent des fragments d'os de la mâchoire montrent des signes de formation d'abcès périapical (une maladie souvent associée

* Department of Anthropology, University of Alberta, Edmonton, AB T6G 2H4, Canada.

** Department of Anthropology, 13-15 Tory Building, University of Alberta, Edmonton AB, T6G 2H4, Canada. Phone: 780/492-3879. Fax: 780/492-5273. (nlovell@ualberta.ca)

aux lésions carieuses), mais aucune différence liée au sexe n'a été observée. La fréquence des caries et des abcès dans cet échantillonnage peut être mise sur le compte d'une consommation d'une alimentation riche en glucides. Plus du deux tiers des adultes sont touchés par le calcul supragingival (tartre). Le calcul est alors lié à la résorption alvéolaire, cette dernière étant une réponse osseuse à la parodontite. Les abcès et la résorption alvéolaire sont à l'origine de la perte de dents ante mortem. On constate une usure fréquente des dents, avec des différences de genre, selon qu'il s'agit d'hommes ou de femmes d'âge moyen.

En dépit des difficultés d'interprétation liées au petit échantillonnage de cette étude et aux problèmes de conservation des spécimens, les résultats de cette analyse sont cohérents avec ceux d'autres rapports publiés en matière de paléopathologie dentaire chez les anciens Egyptiens. On constate que l'usure de la couronne molaire est prononcée, en particulier chez les personnes âgées. L'apparition de ces maladies dentaires s'explique par un régime riche en glucides, à base de pain et d'aliments naturellement sucrés et collants comme les fruits secs et le miel.

Keywords/Mots-clefs: Dental anthropology/anthropologie dentaire, caries, calculus, abscess/abcès, periodontal disease/maladie parodontale, antemortem tooth loss/perte des dents ante-mortem, ancient Egyptians/égyptiens anciens, Mendes.

Introduction

Located in the eastern central delta (Fig. 1), ancient Mendes was occupied continuously for roughly 5,000 years. Mendes functioned variously as a regional capital, hub of trade links throughout the Mediterranean, and religious cult centre associated with the ram god and the fish goddess.[1] Occupation originated in the Predynastic period, but the site eventually fell into disuse and appears to have been largely abandoned by the 1st century BC. The reasons for this are not known precisely, although the city, which relied largely upon irrigation agriculture, may have had difficulty sustaining itself in the face of pronounced variation in the location and flow of the Nile branches. In addition, social strife, indicated by the apparent massacre of inhabitants and the destruction of sacred animal cemeteries, may have caused residents to abandon the city.[2]

Today, the site stretches approximately three kilometres (km) north-south, and somewhat less than one km east-west. Although it has been estimated that the preserved mound constitutes about 80% of the size of the city at the peak of its prosperity,[3] the

[1] Herman De Meulenaere, "Cults and Priesthoods of the Mendesian Nome," in *Mendes II*, ed. Herman De Meulenaere and Pierre MacKay (Warminster: Aris and Philips, 1976), 178-181; Donald B. Redford, "Mendes," in *The Oxford Encyclopedia of Ancient Egypt*, ed. Donald B. Redford. (Oxford University Press, 2001, e-reference edition: http://www.oxford-ancientegypt.com); Susan Redford and Donald B. Redford, "The Cult and Necropolis of the Sacred Ram at Mendes," in *Divine Creatures*, ed. Salima Ikram (American University in Cairo Press, 2005), 164-198.

[2] Donald B. Redford, *City of the Ram-Man* (Princeton: University Press, 2010), 46-50; M. J. Magee, M. L. Wayman, and N. C. Lovell, "Chemical and Archaeological Evidence for the Destruction of a Sacred animal Necropolis at Ancient Mendes, Egypt," *Journal of Archaeological Science* 23 (1996): 484-492.

[3] Redford, City of the Ram-Man, xix.

degree of encroachment by cultivation and the amount of destruction by *sebakheen*[4] suggest that this may be an optimistic estimate. While not necessarily reducing further the scale of the site, looting also has been a problem. Habachi (unpublished) found in 1947 that most tombs were disturbed and the fabric wrappings over the chests of many individuals had been destroyed, almost certainly during searches for amulets and jewelry.[5]

Since the 1960s, extensive excavations have uncovered parts of a Naqada III period settlement, a necropolis for the sacred rams, a temple precinct, residential and industrial areas,[6] and the remains of a satellite mound that may have functioned as a harbour facility and later used as a burial ground and a sacred animal necropolis.[7] Excavation of Predynastic levels at the site have revealed no skeletal remains,[8] but burials that date from the Old Kingdom to Graeco-Roman periods have been found.[9] Further damage to the site, particularly to burials, has been caused by alkaline soils and a fluctuating water table that is influenced by the irrigation of neighbouring fields. As a result of both taphonomic factors and looting, preservation of the human remains often is poor. For example, in one field season only six of 17 skeletons had greater than 90% preservation of elements,[10] with the majority of individuals represented by between 50% and 90% of the 206 bones in the adult skeleton.

Hansen found human burials at the satellite mound of Tell el-Izam[11] (also known and hereafter referred to as Kom el-Adhem)[12] from 1977 to 1978. This mound is composed of sand and sandy soil and there is evidence of an ancient harbour adjacent. The majority of burials at Kom el-Adhem consist of simple sand pits, some topped with mud-brick rectangular outlines, with individuals lying supine. Some bodies appear to have had their internal organs removed and the abdominal cavities filled with rags and molten resin, while others display evidence of wrapping in intricate patterns consistent

[4] Robert K. Holz, "Man-made Landforms in the Nile Delta," *Geographical Review* 59 (1969): 253-269.

[5] Nancy C. Lovell, "The 1992 Excavations at Kom el-Adhem, Mendes," *JSSEA* 21/22 (1992): 20-36.

[6] Donald P. Hansen, "Mendes 1965 and 1966," *JARCE* 6 (1967): 5-51; Redford, "Mendes"; Karen L. Wilson, *Mendes: Preliminary Report on the 1979 and 1980* Seasons (Malibu CA, 1982); Douglas Brewer and Robert Wenke, "Transitional Late Predynastic - Early Dynastic Occupations at Mendes: A Preliminary Report," in *The Nile Delta in Transition: 4th - 3rd Millennium B.C.*, ed. Edwin C. M. van den Brink (Tel Aviv, 1992), 191-197; Redford, City of the Ram-Man.

[7] Lovell, "The 1992 Excavations at Kom el-Adhem, Mendes," *JSSEA* 21/22: 20-36.

[8] Brewer and Wenke, "Transitional Late Predynastic - Early Dynastic Occupations at Mendes: A Preliminary Report."

[9] Hansen, "Mendes 1965 and 1966," *JARCE* 6: 5-51; Lovell, "The 1992 Excavations at Kom el-Adhem, Mendes," *JSSEA* 21/22: 20-36.

[10] Lovell, "The 1992 Excavations at Kom el-Adhem, Mendes," *JSSEA* 21/22: 20-36.

[11] Hansen, "Mendes 1965 and 1966," *JARCE* 6: 5-51.

[12] Lovell, "The 1992 Excavations at Kom el-Adhem, Mendes," *JSSEA* 21/22: 20-36.

with those seen in the Graeco-Roman Period, by which time the art of mummification itself was in decline.

Although several elite tombs have been discovered at the site,[13] the individuals that are the subject of this paper appear to be middle- or working-class, based on burial style, burial location, and the nature of recovered grave goods. Some of these individuals were buried in wooden coffins or reed mats, now largely decayed, but most were not, and none were recovered from tomb structures. A previous study found that these inhabitants of Mendes were in generally good health throughout childhood, although evidence for physiological stress (i.e., development defects in tooth enamel) during the Old Kingdom[14] is consistent with geological, epigraphic, and archaeological evidence for droughts and famines in Egypt during this time.[15] Although important archaeological surveys and excavations have been undertaken in recent decades, the skeletal record for the Egyptian delta is scant, and pathological conditions expressed in the skeleton have been little studied. This report, then, provides additional information on the dental health of the past inhabitants of ancient Mendes, and sheds some light on past dietary behaviours, through the description and analysis of pathological conditions of the dentition, including carious lesions, abscesses, dental calculus, severity of tooth wear, and antemortem tooth loss.

Materials and Methods

Eighty-nine individuals, including infants and children, were recovered during excavations, although the study sample is restricted to the permanent teeth from 69 adults.[16] All of the Old Kingdom and First Intermediate Period remains and some skeletons dating to the Graeco-Roman Period were recovered by the New York University-Institute of Fine Arts Expedition in 1976-78, led by Donald Hanson; Nancy Lovell from the University of Alberta excavated additional material dating to the Graeco-Roman Period between 1991 and 1997. The skeletal material from the NYU excavations was housed at CUNY-Brooklyn until most of it was sent to the University of Alberta in the early 1990s; some additional remains were transferred in 2009. Dental

[13] Redford, City of the Ram-Man, 28-29.

[14] Nancy C. Lovell and Ira Whyte, "Patterns of Dental Enamel Defects at Ancient Mendes, Egypt," *AJPA* 110 (1999): 69-80.

[15] For example, Christopher E. Bernhardt, Benjamin P. Horton, and Jean-Daniel Stanley, "Nile Delta Vegetation Response to Holocene Climate Variability," *Geology* 40(2012): 615-618; and reviewed in Lovell and Whyte, "Patterns of Dental Enamel Defects at Ancient Mendes, Egypt," *AJPA* 110: 69-80.

[16] Although some skeletal remains of children have been recovered from the site, their dental health is very closely tied to a discussion of childhood diet, health, and mortality, which is beyond the scope of this paper.

data collected from those remains by both authors were combined with data collected by Lovell in the field.[17]

Estimation of the age at death for each individual followed standard bioarchaeological protocols[18] and individuals were then categorized as Young Adult (18 to 25 years), Middle Adult (25 to 40 years), Older Adult (>40 years), or Adult-unknown (clearly adult, but of uncertain age in years) in order to facilitate further analysis. Sex was determined on the basis of secondary sex characteristics as exhibited in the adult skeleton and the individuals were then characterized as Female, Male, or Indeterminate. The particulars of age and sex for each pathological condition vary according to the number of teeth that can be observed for analysis, and therefore are presented in tabular detail only for the conditions reported. Overall, however, males and females were fairly equally represented and individuals of indeterminate sex made up 20% of the sample. Middle-aged adults comprised over half of the sample when it was partitioned by age; this is probably due to a combination of the difficulty in obtaining precise age estimates for adult skeletons and the typical life expectancy in antiquity, and so is not thought to cause problems for this analysis.

A total of 714 teeth were preserved and observable for pathological conditions. Thus, the total observable sample is only 32% of the size of the dental sample that would be expected if all individuals had possessed a full set of teeth (expected N=2208).[19] This can be attributed to problems of preservation (which is not uncommon when dealing with archaeological human remains in many parts of the world, particularly those remains that have not been protected in burial shafts or containers) and to the postmortem loss of teeth during excavation and subsequent handling.

Identifiable teeth and fragments of the maxillae and mandibles were examined, inventoried, and their pathological lesions scored according to accepted disciplinary standards.[20] Severity of tooth wear and calculus; the presence, severity, and location of

[17] Nancy Lovell thanks Douglas Brewer, Donald Redford, Susan Redford, and Robert Wenke for their assistance with the University of Alberta's excavations at Mendes; and Bonnie Gustav Golub, Christine Lilyquist, and the late Donald Hansen for providing access to burial records and the skeletal remains recovered by the NYU-IFA Expedition. Nancy Lovell's excavations at Mendes from 1991-1997 and associated skeletal analyses were generously funded by grants from the Social Sciences and Humanities Research Council of Canada and the University of Alberta.

[18] Age-at-death estimation and determination of sex followed the procedures outlined by Jane E. Buikstra and Douglas H. Ubelaker eds., *Standards for Data Collection from Human Skeletal Remains* (Fayetteville: Arkansas Archaeological Survey, 1994).

[19] The normal complement of permanent teeth in the adult dentition is 32; hence, the expected sample size of teeth for 69 individuals with permanent dentitions is 2208.

[20] Dental inventory followed Buikstra and Ubelaker, Standards for Data Collection from Human Skeletal Remains. Occlusal wear was scored following the method described by B. Holly Smith, "Patterns of Molar Wear in Hunter-gatherers and Agriculturalists," *AJPA* 63 (1984): 39-56. The initiation sites and recording of carious lesions followed Simon Hillson, *Dental Anthropology* (Cambridge University Press, 1996), Table 12.3. Calculus

carious lesions; and the presence of periapical abscesses were recorded for all observable teeth and alveoli. Antemortem tooth loss was recorded in cases of missing teeth when the alveolus exhibited a reactive process of bone resorption and/or deposition (i.e., healing); in cases of missing teeth where the alveolus was un-remodeled the tooth was assumed to have been lost postmortem. Teeth that were too fragmentary to identify were not included in the study, and those that were unobservable for particular features were omitted from certain analyses. Inter- and intra-observer error in the assessment of pathological lesions was assessed through re-scoring of 10% of the sample and found to be negligible.

Results and Discussion

Tooth Wear

Mean tooth wear scores for selected teeth in this sample are presented in Tables 1 and 2, for males and females respectively. The patterns conform to what would be expected given the tendency among agriculturalists to show heavier wear on the posterior teeth compared to the anterior teeth, and for the first permanent molar to exhibit greater wear because of its use in mastication from the age of about six years. Although the degree of wear in both males and females during the First Intermediate Period is greater than in other time periods, this could easily be an artifact of small sample sizes and the number of missing values in some categories; at present there are no social-cultural data for this period at Mendes to indicate that the differences represent different diets, for example.

Tooth wear is generally divided into two categories, based on the material causing the wear: dental attrition is the loss of enamel due to tooth-on-tooth contact while dental abrasion is caused by foreign substances. Archaeological and historical records can provide clues to causes of abrasion through information about the ancient Egyptian diet. According to one review, tooth wear was more severe in Upper Egypt than in Lower Egypt, and decreased in severity from the Predynastic to the Dynastic time periods; these trends likely reflect differences in food preparation among cultural groups, as well as changes in processing techniques over time.[21] Querns and other stone grinding implements appear in the archaeological record of ancient Egypt, as well as in ancient artistic depictions,[22] and may have introduced abrasives to food. One study

was scored for each tooth using a three-point system described by Don R. Brothwell, *Digging Up Bones*, 3rd ed. (London/Oxford: British Museum and Oxford University Press, 1981).

[21] Jerome C. Rose, George J. Armelagos, and L. Stephen Perry. "Dental Anthropology of the Nile Valley," in *Biological Anthropology and the Study of Ancient Egypt*, ed. W. Vivian Davies and Roxie Walker (London: British Museum Press, 1993), 61-74.

[22] Frank Filce Leek, "Teeth and Bread in Ancient Egypt," *JEA* 8 (1972): 126-132; Delwen Samuel, "Ancient Egyptian Bread and Beer: An Interdisciplinary Approach," in *Biological Anthropology and the Study of Ancient*

found a high amount of inorganic material in samples of ancient Egyptian bread as compared to breads from other geographic and temporal periods.[23] Although limited in scope, microwear studies on ancient Egyptian teeth have found, however, a lack of the striations that are normally associated with large abrasive particles, which suggests that finer particles are responsible for wear in at least some individuals.[24] Tough, fibrous foods have been associated in the Nile Valley with this particular "polishing" pattern of wear and reflect a potential dietary cause outside of grain processing and consumption.[25] Fine abrasives could have come from other dietary staples, such as chickpeas or beans, depending upon the preparation and cooking methods. In addition, the chewing of masticatories, such as wads of papyrus, to stimulate saliva flow could cause dental polishing.

Sex differences in tooth wear have been documented in different populations and attributed to specialized gender roles and activities.[26] Because of sample sizes, mean tooth wear scores for females in this sample can be compared only to male scores within the Middle Adult age category in the First Intermediate Period and within the Young Adult age category of the Greco-Roman period, but results indicate that females have more severe wear than males. This may reflect higher consumption of abrasive food by females, although gendered activities that involved the use of teeth as tools also may be implicated. Women were responsible for household weaving and the processing of flax into linen throughout most of ancient Egyptian history, for example, although such habitual activities, if they involved the teeth, might have caused more localized wear. The evidence for sex differences in tooth wear at Mendes is not conclusive and may, in fact, be due to age differences, given the broad age ranges to which we were able to assign individuals.

Caries

Tables 3 and 4 show the tooth count and individual count frequencies of dental caries in permanent teeth at Mendes. Dental caries is an infectious disease that causes the destruction of dental tissues by acid that is produced by oral bacteria. Carious lesions characteristically first appear as brownish discolourations or pits on the enamel covering the tooth crown, and may progressively destroy the underlying dentin. The

Egypt, ed. W. Vivian Davies and Roxie Walker (London: British Museum Press, 1993), 156-164; Barry J. Kemp, *Ancient Egypt: Anatomy of a Civilization* (New York: Routledge, 2006), 172.

[23] Leek, "Teeth and Bread in Ancient Egypt," *JSSEA* 8: 126-132.

[24] Rose et al., "Dental Anthropology of the Nile Valley," 61-74.

[25] Rose et al., "Dental Anthropology of the Nile Valley," 61-74; Bob Brier and Hoyt Hobbs, *Daily Life of the Ancient Egyptians* (Westport, CT: Greenwood Press, 2008).

[26] Stephen Molnar, "Sex, Age and Tooth Position as Factors in the Production of Tooth Wear," *Am Antiquity* 36 (1971): 182-188.

cementum that covers the tooth root is softer than enamel and thus is more susceptible to caries; the root can be affected by caries if it is exposed through the development of periodontal disease, a condition that may cause retraction of gum tissue.

A number of factors influence the frequency and prevalence of caries in a given population. Diets high in carbohydrates, starches, and refined sugars tend to increase caries frequency and severity. The morphological characteristics of certain teeth also can promote caries formation, with pits, grooves, and fissures being potential sites for the accumulation of food particles on which oral bacteria feed. Because of their complex crown morphology, molars and premolars therefore tend to be more affected than incisors and canines. In addition, spaces between adjacent teeth, typically below their contact points near the gum line, trap food particles leading to the development of interproximal lesions. Consistent with these factors, teeth with complex morphology have the highest frequencies of lesions (Table 3), and interproximal and occlusal lesions in this sample are more common than are lesions appearing on smooth surfaces of the crown or on the root.

Factors specific to individuals (e.g., thickness of dental enamel, the presence of enamel defects, and the amount of oral bacteria that are responsible for plaque formation) also influence the development of carious lesions. These factors must be considered when the pattern of lesions shows an individual to be an outlier compared to the rest of the sample, but no unusual patterns were observed.

Tooth wear can affect both the manifestation of carious lesions and their scoring. Abrasion of the occlusal tooth surface can remove early stage lesions before they progress to further destruction of the enamel, and the substances that cause abrasion may serve to cleanse the teeth of plaque and food particles, reducing the risk of caries development. Most noticeably, however, severe occlusal wear can lead to the antemortem loss of teeth. Although caries correction factors have been developed to address this problem[27] the small sample size and the fragmentary nature of the teeth led us to conclude that correction calculations would not be helpful. However, as seen in Figure 2, occlusal wear seems to have proceeded slowly enough to allow secondary dentin to the pulp chamber, protecting it from exposure that eventually leads to pulp necrosis and loss of the tooth. Regardless, the prevalence of carious lesions reported for this sample should be considered a minimum estimate.

Individual count frequencies of dental caries (Table 4) show a higher percentage of males affected than females (35% and 30% respectively), although this result is not statistically significant and shouldn't be considered meaningful due to the small and unequal samples sizes and the fact that four individuals with caries could not be sexed.

[27] John R. Lukacs, "The 'Caries Correction Factor': A New Method of Calibrating Dental Caries Rates to Compensate for Antemortem Loss of Teeth," *Intl J Osteoarchaeol* 5 (1995): 151-156; Yilmaz S. Erdal and Izzet Duyar, "A New Correction Procedure for Calibrating Dental Caries Frequency," *AJPA* 108 (1999): 237-240.

Upon examination of the individual count prevalence of caries across time periods (Table 4), the Greco-Roman period shows the greatest number of affected individuals, at 46% of the sample. This is followed by the First Intermediate (30%) and Old Kingdom periods (10%). However, the numbers of observable individuals from each period are unequal, with the number of individuals recovered from the First Intermediate Period contexts being especially low. Thus, again, these differences cannot be shown to be statistically significant.

Much attention has been paid to temporal changes in frequencies of caries and the role of the Egyptian diet in mediating these changes.[28] In general, the ancient Egyptian diet for middle class individuals is thought to have consisted mainly of bread, beer, fruit, and vegetables, with fish and poultry the main protein sources. Honey was used as a sweetener, but actual refined sugars were not introduced into Egypt until the Islamic era. Soft, sticky fruits such as figs and dates, as well as dried fruits, tend to adhere to the surfaces of teeth and facilitate the development of carious lesions. Although these fruits might be considered luxury goods more common to the diets of elite members of Egyptian society, alternatively they may have served as a compact and easily portable source of energy that has no special storage requirements, and thus may have supplemented the daily food rations among labourers and household workers alike.

At 6%, the tooth count frequency of caries in this study is only slightly greater than the maximum (ranges of 0.4% to 4.65%) reported for other Egyptian samples (Table 3). The individual prevalence of 33% also falls within the range of 10 to 42% for ancient Nubian and Egyptian sites. Differences between male and female individual prevalence are evident in all time periods represented in this study, but are inconclusive due to the small sample size and the effect of individuals of unknown sex. However, caries prevalence appears to be higher in females in most populations. Sex differences in caries prevalence have been explained as the effect of dietary differences between sexes or due to a gendered division of labour, such as food processing and cooking activities that increase the risk of caries for females.[29] But biological differences also play a role in the higher caries prevalence in females. These differences include the earlier eruption of teeth in females (with a slightly longer tooth exposure to cariogenic conditions); differences in bacterial and salivary components related to mineralization and oral pH; and the female life history. Aspects of a woman's reproductive biology, including

[28] For discussions of diet and dental disease, see Simon Hillson, "Diet and Dental Disease," *World Archaeology* 11 (1979): 147-162; Simon Hillson, *Dental Anthropology* (Cambridge: Cambridge University Press, 1996); Rose et al. "Dental Anthropology of the Nile Valley," 61-74; Judith Miller, *An Appraisal of the Skulls and Dentition of Ancient Egyptians, Highlighting the Pathology and Speculating on the Influence of Diet and Environment* (Oxford: Archaeopress, 2008).

[29] Molnar, "Sex, Age and Tooth Position as Factors in the Production of Tooth Wear," *Am Antiquity* 36 (1971): 182-188; Hillson, *Dental Anthropology.*

puberty, menses, and pregnancy, may predispose her for dental caries.[30] For example, women who experience "morning sickness" during pregnancy may develop weakening of their tooth enamel due to exposure to corrosive stomach acids. In addition, dietary choices that are influenced by the increased caloric requirements of pregnancy and nursing also may increase the likelihood of caries in women.

In the absence of epigraphic or other evidence for preferential feeding of male over female infants[31] and the relative equality of the economic features of the Mendes burials discussed here, any sex difference in caries frequencies in this sample likely reflect biological factors rather than cultural practices.

Abscesses

The main cause of abscess formation is the invasion of the tooth pulp cavity by infectious bacteria, which occurs either through occlusal wear or carious destruction of the tooth crown. If the infection persists, the body attempts to isolate the infected area by forming a pus drainage channel to prevent the spread of the bacteria. Loss of the tooth, or teeth, is a common sequel to abscesses because of the loss of bony support for the tooth.

Periapical abscessing is found in a great number of skeletal collections from Egypt and Nubia[32] and in this study was observed in 12 individuals of the 40 that had sufficiently well-preserved maxillae and mandibles for examination. The abscesses took the form of drainage channels for pus either between teeth or on the buccal side of the alveolar bone (Fig. 3). Females were more affected than were males, overall (Table 5), but the impact of unknown sex on the accurate determination of sex differences in abscess prevalence or in differences between the time periods, below, cannot be determined.

As shown in Table 5, 8% of observable individuals from the Old Kingdom period, 22% from the First Intermediate period, and 36% of individuals from the Greco-Roman period exhibited abscesses, a trend that mimics caries prevalence. This trend is unsurprising since the two conditions are causally linked. With past historical and

[30] John R. Lukacs and L. Largaespada, "Explaining Sex Differences in Dental Caries Rates: Saliva, Hormones and "Life History" Etiologies," *Am J Hum Biol* 18 (2006): 540-555; John R. Lukacs and Linda M. Thompson, "Dental Caries Prevalence by Sex in Prehistory: Magnitude and Meaning," in *Technique and Application in Dental Anthropology*, ed. Joel D. Irish and Greg C. Nelson (Cambridge: Cambridge University Press, 2008), 136-177.

[31] Lovell and Whyte, "Patterns of Dental Enamel Defects at Ancient Mendes, Egypt," *AJPA* 110: 69-80.

[32] Tammy R. Greene, *Diet and Dental Health in Predynastic Egypt: A Comparison of Hierakonpolis and Naqada* (PhD thesis, University of Alaska Fairbanks, 2006); Moustafa A. Ibrahim, *A Study of Dental Attrition and Diet in Some Ancient Egyptian Populations* (PhD thesis, University of Durham, 1987); Leek, "Observations on the Dental Pathology Seen in Ancient Egyptian Skulls," *JEA* 52: 59-64; Patricia V. Podzorski, *Their Bones Shall Not Perish* (New Malden, Surrey: SIA Publishing, 1990), 55-56; Eugen Strouhal, *Life of the Ancient Egyptians* (Liverpool: Liverpool University Press, 1997), 249-250.

epigraphic evidence of famines and droughts during the Old Kingdom, it is possible that shortages prevented the consumption of grains as well as dried fruits and other dietary sugars. This in turn may have lessened the cariogenic impact of the Egyptian diet in this time period, resulting in fewer carious lesions, and hence fewer abscesses. As with caries prevalence, however, the small sample sizes prevent any confident inferences about temporal trends in abscess prevalence.

Calculus

Calculus forms from the mineralization (largely by calcium carbonate, apatite, and brushite) of the invisible plaque that covers tooth surfaces. The mineral component derives from the saliva and, thus, the tooth surfaces closest to the salivary glands, i.e., those on the tongue side of the lower incisors, tend to be the most affected.[33] Although the identification of the primary dietary component that favours calculus formation is the subject of some debate,[34] calculus distribution is linked to the accumulation of plaque, which is increased by carbohydrate consumption and poor oral hygiene. Some individuals exhibited no calculus on their teeth, while others displayed large supra-gingival accumulations (Fig. 4). Forty-eight of the 67 individuals (72%) showed calculus deposits of varying severity (Table 6), with males more often affected than females.

Previous studies of dental disease in ancient Egyptian and Nubian populations found that calculus was more prevalent in females (90%) than males (70%), and increased as age increased.[35] (Although it is possible to scrape calculus from the tooth after its formation, in the living individual it continues to accumulate over time unless intentionally removed and remains on the teeth after death.) The observation in this study of higher male prevalence may be due to geographic and temporal differences (i.e., between the large numbers of individuals from Upper Egypt and Nubia that were examined in other studies and the small number of individuals from Mendes in Lower Egypt), to the lack of precision in age at death estimates, or to the obscuring of gendered differences in prevalence by the number of individuals of unknown sex. As is commonly noted in bioarchaeological studies, larger sample sizes and improved methods of adult age-at-death estimations will be needed before issues such as these can be satisfactorily resolved.

Calculus prevalence appears to be stable, at 80%, from the Old Kingdom to the First Intermediate Period, but decreases to 65% in the Greco-Roman period (Table 6). Due to the unequal number of individuals in each time period, however, the decrease in

[33] Hillson, Dental Anthropology, 255.

[34] For a review, see Angela R. Lieverse, "Diet and the Etiology of Dental Calculus," *Int J Osteoarchaeol* 9 (1999): 219-232.

[35] Hillson, "Diet and Dental Disease," *World Archaeology* 11: 147-162.

calculus prevalence over time does not provide conclusive evidence of temporal changes in diet or hygiene habits.[36] Furthermore, calculus deposits can be dislodged from the tooth before or after death, and therefore may be underrepresented in one or another of the sub-samples investigated here.

It is possible that the formation of calculus among individuals living at Mendes was influenced by the alkaline nature of the soils, a problem that can arise from irrigation with water that is high in soluble salts. Although relationships between dental health and some mineral components of water are well known (e.g., fluoride), the link between soil pH and calculus formation is not satisfactorily documented.

Antemortem Tooth Loss

The impact of dental disease and tooth wear on antemortem tooth loss for this particular sample cannot be fully appreciated due to the lack of preserved alveolar bone. Tooth wear may act to remove the carious lesions before they penetrate into the pulp cavity of the tooth, but additionally it may create new sites for lesions to develop.[37] However, even with the high tooth wear scores found in this sample, no exposed pulp cavities were observed, other than those caused by carious lesions. A possible explanation for antemortem tooth loss in this sample may, therefore, involve both the presence of calculus (causing gingival recession) and the forces involved in tooth abrasion. Both of these can cause alveolar resorption and loss of bone support for the tooth. Abrasive exposure of the pulp cavity and subsequent infection may actually be a less common consequence of a carbohydrate-based diet than originally thought.[38]

Conclusions

The frequencies of dental disease at Mendes are similar to those reported for other parts of ancient Egypt. When considering the middle-class status of the individuals represented in this study, the dental disease and tooth wear frequencies and prevalence are consistent with a habitually abrasive carbohydrate-based diet. Sex differences in caries prevalence and abscess formation at Mendes are not especially clear, although

[36] Although a variety of cosmetic implements have been depicted in, and recovered from, ancient Egyptian tombs, nothing resembling a "toothbrush" has ever been identified. Ancient Egyptians may have used the frayed end of a freshly harvested twig as a toothbrush; chewing twigs taken from the arak tree are known historically and ethnographically in regions of the Sahara, as are twigs from the neem tree in South and Southeast Asia. These are easily disposed of after use and are unlikely to be identified in archaeological context even if preserved. Their use, however, does not seem to be recorded in any of the Egyptian medical papyri, even though the use of masticatories to sweeten the breath is recorded.

[37] Simon Hillson, "The Current State of Dental Decay," in *Technique and Application in Dental Anthropology*, ed. Joel D. Irish and Greg C. Nelson (Cambridge: Cambridge Press, 2008), 111-135.

[38] Richard T. Koritzer, "An Analysis of the Cause of Tooth Loss in an Ancient Egyptian Population," *Am Anthropol* 70 (1968): 550-553; Leek, "Observations on the Dental Pathology Seen in Ancient Egyptian Skulls," *JEA* 52: 59-64.

males tended to be affected more by calculus and caries and females by abscesses. This last finding suggests that tooth wear, which is more severe among females than males, is a significant contributor to tooth infection and, hence, subsequent abscessing. Unsurprisingly, the degree of tooth wear was found to increase with age.

Although the sample size in this study is small and there are significant limitations to any inferences about the larger population, there are only a small number of publications that examine dental disease and tooth wear in skeletal remains from this part of Egypt. Thus, the data presented here may be useful to other researchers who are interested in reconstructing dental health and dietary behaviours of the ancient Egyptians. Certainly, it will be of interest to compare these results to larger datasets, particularly those stemming from controlled bioarchaeological excavations. Further dental material from Mendes needs to be examined in order to increase the sample size and ensure more equal representation of the various time periods and age categories. This would allow within-sample comparisons and stimulate further discussion about dental disease and tooth wear at Mendes, and could lead to a more nuanced assessment of possible dietary and masticatory activities among communities in different geographic regions of ancient Egypt.

Table 1: Mean tooth wear score per selected tooth class for males
(OK = Old Kingdom, FIP = First Intermediate Period, GR = Graeco-Roman Period;
*** indicates that no teeth were observable in this category)**

	Young Adult			Middle Adult			Older Adult			# of observable teeth
	OK	FIP	GR	OK	FIP	GR	OK	FIP	GR	
Central Incisor	5	*	2.7	3.6	4.7	4.1	*	*	*	38
Canine	3	*	2.5	3.4	4.4	3.3	*	*	4	35
1st Premolar	3.6	*	2.1	4	4.4	3.7	*	*	3.3	34
1st Molar	4.5	*	3.3	5.3	5.8	4.9	*	*	4	43

Table 2: Mean tooth wear score per selected tooth class for females.
(OK = Old Kingdom, FIP = First Intermediate Period, GR = Graeco-Roman Period;
* indicates that no teeth were observable in this category)

	Young Adult			Middle Adult			Older Adult			# of observable teeth
	OK	FIP	GR	OK	FIP	GR	OK	FIP	GR	
Central Incisor	*	3	3.1	4.2	5.6	4	*	*	5	44
Canine	*	1.3	3.4	3.7	4.7	4	*	*	4.7	39
1st Premolar	*	1	3.8	4.5	5.4	3.4	*	*	5.5	36
1st Molar	3	2.5	4.8	5.7	7	3.6	*	*	6	33

Table 3: Tooth count frequencies of carious lesions at Mendes.
(n = number of affected teeth; N = number of observable teeth.)

Tooth Type	n	N	%
Upper Incisors	2	79	3
Upper Canines	2	49	4
Upper Premolars	3	83	4
Upper Molars	16	145	11
Lower Incisors	1	77	1
Lower Canines	0	49	0
Lower Premolars	1	87	1
Lower Molars	17	145	12
Total	42	714	6

Table 4: Individual count prevalence of caries at Mendes, by sex, for the Old Kingdom, First Intermediate, and Graeco-Roman Periods. (n = number of affected individuals; N = number of observable individuals.)

Time Period	Sex								
	Male		Female		Unknown		Total		
	n	%	N	%	n	%	n	N	%
Old Kingdom	1	10	1	11	0	0	2	20	10
First Intermediate	6	17	2	67	0	0	3	10	30
Graeco-Roman	9	60	4	36	4	36	17	37	46
Total	11	35	7	30	4	31	22	67	33

Table 5: Individual count prevalence of abscesses at Mendes, by sex, for the Old Kingdom, First Intermediate and Greco-Roman periods.
(n = number of affected individuals; N = number of observable individuals.)

Time Period	Sex								
	Male		Female		Unknown		Total		
	n	%	N	%	n	%	n	N	%
Old Kingdom	0	0	1	14	0	0	1	12	8
First Intermediate	1	20	1	33	0	0	2	9	22
Graeco-Roman	3	27	4	44	2	40	9	25	36
Total	4	9	6	13	2	4	12	46	26

Table 6: Individual count prevalence of calculus at Mendes, by sex, for the Old Kingdom, First Intermediate and Greco-Roman Periods.
(n = number of affected individuals; N = number of observable individuals.)

Time Period	Sex								
	Male		Female		Unknown		Total		
	n	%	N	%	n	%	n	N	%
Old Kingdom	9	90	7	78	0	0	16	20	80
First Intermediate	5	83	3	100	0	0	8	10	80
Graeco-Roman	11	73	8	73	5	45	24	37	65
Total	25	37	18	27	5	7	48	67	72

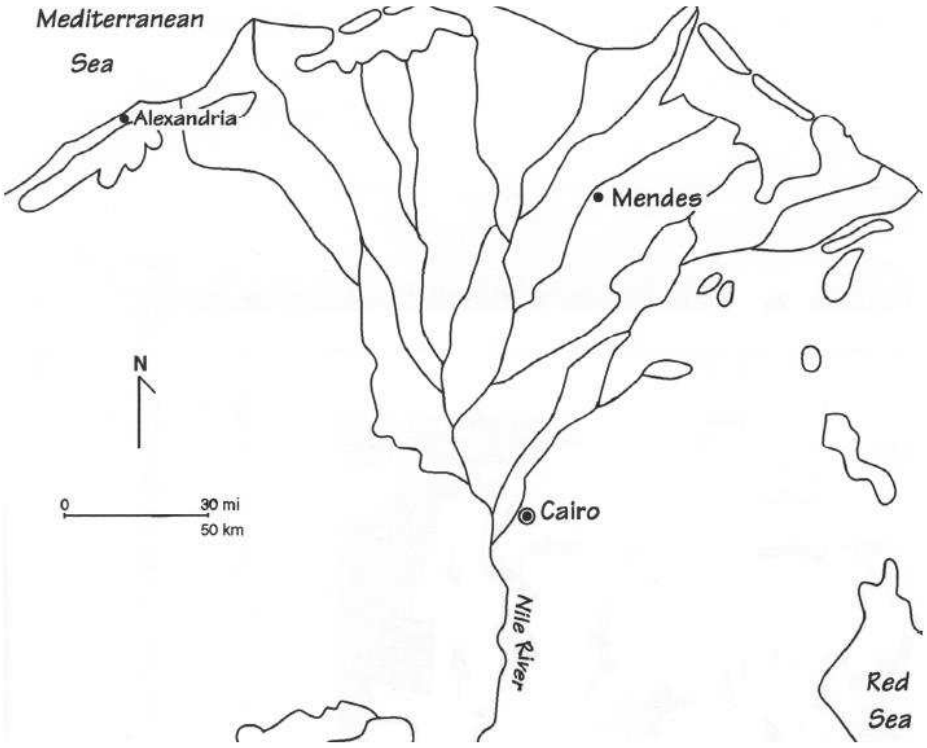

Fig.1: Map of the Egyptian delta showing the location of ancient Mendes.

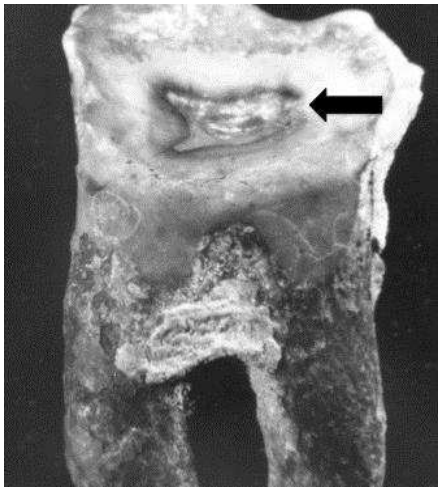

Fig. 2: Severe occlusal wear of a mandibular molar, showing obliteration of the crown but in-fill of the pulp cavity by secondary dentin (arrow).

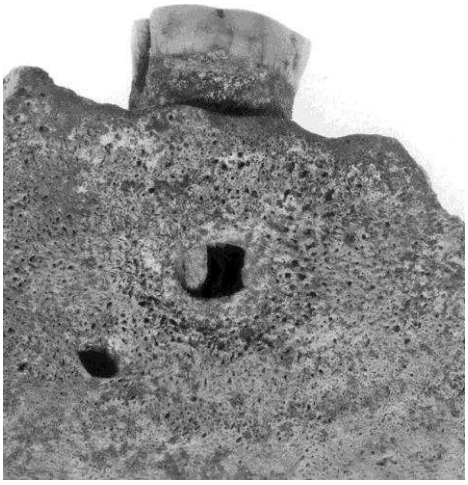

Fig. 3: Portion of a mandible showing a periapical abscess. The root apex is visible in the opening in the bone.

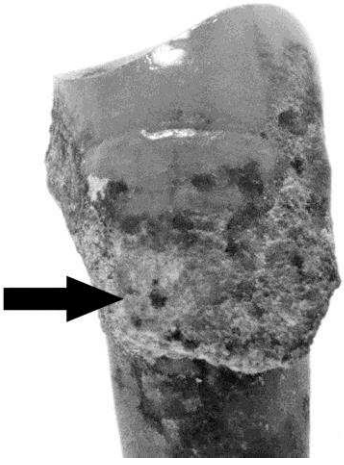

Fig. 4: Lower canine tooth illustrating a severe grade of calculus (arrow).