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Patterns of Activity-Induced Dental Abrasion in a Skeletal Sample from Ancient Mendes, Egypt

by

© Kimberley Elena Palichuk

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Master of Arts.

Department of Anthropology

Edmonton, Alberta

Fall 1994

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled "Patterns of Activity-Induced Dental Abrasion in a Skeletal Sample from Ancient Mendes, Egypt" submitted by Kimberley Elena Palichuk in partial fulfillment of the requirements for the degree of Master of Arts.

Nancy C. ~~Lovell~~

Sharon M. Compton

Michael L. Wayman

Pamela R. Willoughby

For my parents

ABSTRACT

Patterns of dental wear in skeletal samples often reveal information about the diet, subsistence technology, food preparation methods, and occupational or habitual activities of ancient peoples.

In this study, 317 teeth from 26 individuals dating to Old Kingdom, First Intermediate Period/Middle Kingdom, and Ptolemaic levels from the site of Mendes in the Nile Delta were examined for evidence of non-masticatory or activity-induced dental abrasion. Thirteen individuals displayed unusual patterns of wear, including chipping, flat root wear, flat facial wear, flat cemento-enamel junction wear, oblique labial/buccal wear, oblique lingual wear, oblique mesio/distal wear, interproximal wear, and saddle-shaped wear.

Interpretations of these macroscopically visible wear patterns, aided by statistical analysis, scanning electron microscopy, Egyptian archaeological and literary sources and ethnographic comparisons with ancient and modern groups, suggest that activities such as quid chewing, leather working, fibre or sinew processing, splitting reeds or papyrus for weaving, and the crafting of stone tools are possible etiological factors.

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Dental wear studies of archaeological populations have provided researchers with information regarding the diet, food preparation methods, masticatory movements, and occupational activities of ancient peoples. Although much of the work that has been done in this area has focused on patterns of occlusal tooth wear (e.g. Anderson 1965; Patterson 1984, 1986; Smith 1972), there is also a growing body of research dedicated to the interpretation and analysis of non-masticatory, activity-induced patterns of dental abrasion (e.g. Lukacs and Pastor 1988; Molnar 1971, 1972; Schulz 1977). These studies are of great value for increasing our understanding of the daily lives of ancient peoples, because they provide a record of occupational, habitual, or compulsive behaviors.

This thesis is a contribution to the understanding of habitual and occupational behavior patterns among ancient Egyptians through the analysis of human dental remains from ancient Mendes. Mendes (known in modern times as Tell el-Rub'a), is one of the largest and best preserved town sites in the Nile Delta. Archaeological and literary evidence indicate that the site functioned as both an administrative capital and a cult centre, and was continuously occupied from the Predynastic to the Ptolemaic periods (c. 4,000 B.C. to c. 30 B.C.) (Brewer and Wenke 1992; Landy 1979; Redford 1988). This study has three aims: to document unique dental wear patterns within the skeletal sample; to detect any patterns or changes in wear frequencies over time; and to relate the wear patterns observed to behavioral patterns in ancient Egypt. A variety of resources are drawn upon to aid interpretation and analysis, including macroscopic examination, statistical analysis, scanning electron microscope (SEM) technology, ethnographic comparisons with other groups, archaeological evidence, and ancient art and literature.

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CHAPTER 2: STUDIES IN MASTICATORY AND NON-MASTICATORY DENTAL WEAR

INTRODUCTION

Dental wear studies have provided researchers with much information regarding the diet, subsistence methods, masticatory movements, and occupational activities of ancient peoples. In the past, much of the work in this area has focused on analyzing patterns of occlusal tooth wear (e.g. Anderson 1965; Patterson 1984, 1986; Smith 1972). More recently, however, there has been an increasing emphasis in the literature on non-masticatory forms of tooth wear and their significance in reconstructing past human behavior (e.g. Lukacs and Pastor 1988; Molnar 1971a, 1972). Activity-induced dental wear patterns can be of great value for increasing our understanding of the daily lives of ancient peoples, since they provide a record of occupational, habitual, or compulsive behaviors. As these studies have progressed, a variety of analytical tools have been relied upon in order to better facilitate interpretation, including ethnographic comparisons with other groups, archaeological sources, ancient art and literature, and scanning electron microscopy (SEM). This review will provide a brief account of some of the ways these analytical tools have been utilized for research into dental wear, followed by an in-depth account of developments in the study of intentional and unintentional modification of human teeth.

Developments in Scoring Dental Wear

Research involving dental wear often involves comparisons: between different time periods, geographical areas, sexes, or tooth types. In order to make these comparisons meaningful, tooth wear data should be recorded using standardized methods. One of the earliest methods created for scoring dental wear was Broca's classification system, which dates back to 1879 (Pindborg 1970). This system was based upon a five-point scale of occlusal wear grades, ranging from absence of wear (level 0) to complete obliteration of the tooth crown (level 4). Later methods incorporated Broca's principles, but also added more specific criteria for scoring tooth wear. Murphy's (1959) system, for example, scores molar wear based on the degree of dentine exposed, and compares exposure rates between molars as well as between jaws. Molnar's (1971a) method, in contrast, scores three separate aspects of dental wear: degree of dentine exposure, direction of wear, and occlusal surface form. An alternative technique, developed by Scott (1979), scores the amount of enamel left on the tooth, as opposed to recording the amount of dentine exposed. This method divides the molar into four quadrants and scores each quadrant separately using a scale of 0 to 10. An overall wear score is then calculated based on the sum of the quadrants.

Further refinements of wear scoring methods compared wear-plane angles between molars that showed the same degree of occlusal tooth wear. This technique was developed in order to facilitate standardized comparisons between groups that relied upon different subsistence techniques, and that therefore may have experienced different rates of wear (Smith 1984).

Occlusal Wear Planes and the Evolution of the Human Dental Apparatus

The study of dental wear planes has not only been of use for comparing wear rates between different groups, but also for improving our understanding of how the teeth and jaws respond to masticatory forces. One early study in this area documented changes in the occlusal tooth plane of Maori and Moriori groups from New Zealand and Chatham Island, and related these changes to increases in overall tooth wear caused by diet (Taylor 1963). The importance of mastication forces in the formation of occlusal wear planes has also been acknowledged. In one study, jaw movements during the mastication process were simulated by a machine, in order to determine how certain motions and forces cause different types of tooth wear (Brace and Molnar 1967).

A major advance in the study of occlusal wear planes occurred with the identification of the helicoidal pattern of dental wear. This wear pattern was first identified among Alaskan Eskimos in 1933 by F. Ackermann (Ackermann 1963). It is characterized by the sloping of maxillary and mandibular molars in opposite and complementary directions as wear levels increase (Hall 1976). The relationship between the helicoidal wear pattern, degree of wear, and diet has been studied among numerous early populations, including British Columbia Indians, Huron Indians, Maori, Australian Aborigines, and Egyptians (Hall 1976; Roydhouse and Simonsen 1975).

Tooth Wear and Estimation of Age at Death

One of the areas in which standardized scoring methods have been useful has been for the estimation of age at death because estimates are often skewed by various factors such as sex, diet, or cultural factors (Brothwell 1981). One way in which this problem has been dealt with has been to document tooth eruption patterns and wear gradients at each stage of eruption among subadults in the sample. A standard rate of wear is determined from these observations and is then applied to older individuals in order to estimate age (Miles 1963). This technique has been used, for example, to determine age at death in the Tepe Hissar skeletal sample from Iran (Nowell 1978), and in the Libben sample from the northeastern United States (Lovejoy 1985).

Occlusal Tooth Wear and Diet

Many dental wear studies in anthropology have concentrated on occlusal tooth wear, because of the information it can yield about the dietary patterns and subsistence techniques of ancient peoples. These studies are of significance because they provide a record of some of the effects of cultural, economic, and dietary changes over time. There is a large body of work in this area, dating back to 1920, when Ruffer reviewed Egyptian dental conditions from the Predynastic to the Coptic periods and concluded that the heavy wear he observed was due to the coarse nature of the Egyptian diet (Ruffer 1920). Early studies on Eskimo and Greenlander dentitions also related heavy tooth wear to dietary causes (Leigh 1925; Pederson 1938).

Additional studies of occlusal tooth wear and diet include an analysis of how changes in dental wear were related to changes in economy and diet at Tehuacan (Anderson 1965); an analysis of the relationship between wear gradients, dietary and cultural differences among three Natufian groups (Smith 1972); and a study of the relationship between dental wear and the emergence of horticulture among the Iroquois (Patterson 1984, 1986). Further documentation of the connection between environment, subsistence, and dental wear was provided in a comparison of wear patterns among several groups of Australian Aborigines from various sites (Molnar et al. 1989).

Aesthetic Modifications

Intentional dental modification for ritual or decorative purposes is a form of tooth wear that is particularly indicative of cultural practices and beliefs of ancient and modern groups. It is also a significant part of dental wear studies because of its prevalence in many areas in the world. Dental modifications have been reported among people in West Africa (Goose 1963), Central Africa (Walker and Hewlett 1989), North America (Willey and Ubelaker 1976), Middle America (Romero 1970); India (Kennedy et al. 1981), and the Caribbean (Handler et al. 1982). One issue that should be addressed by researchers studying this type of wear is the distinction between intentional and unintentional dental modification. This distinction is not always clear, so a model for differential diagnosis has been introduced (Blakely and Beck 1984). The use of criteria such as sex differences, teeth affected, and symmetry of pattern are all recommended to help determine whether observed wear was due to tooth-tool use or intentional modification (Blakely and Beck 1984).

Non-dietary Causes of Tooth Wear

The use of teeth as tools or for other non-masticatory functions has long been recognized in both dental and anthropological literature as a contributing factor in the production of dental wear. Modern accounts of occupational tooth wear have identified various activities that result in enamel abrasion, such as holding objects between the anterior teeth as practiced by seamstresses, shoemakers, carpenters, and upholsterers; excessive toothbrushing; and habits such as pipe-smoking (Pindborg 1970; Schour and Sarnat 1942).

Many anthropological studies on the dental conditions of ancient and modern peoples have also noted the contribution of nonalimentary tooth use towards general wear levels (e.g. Dahlberg 1963; Leigh 1925; Moorrees 1957; Pederson 1938, 1952). A study of modern Eskimo, Baining, and Lapp populations described tooth-tool activities such as cleaning hides and softening thread, extracting dye from bark, and operating bow drills (Lous 1970). None of these early works, however, addressed the question of how specific activities would be reflected in the teeth. It was Molnar's (1971a, 1971b, 1972) research that identified the importance of relating patterns of tooth wear not only to the dietary habits of past peoples, but to nondietary habits such as tooth-tool use as well. He recognized the relationship between distinct types of wear and tooth-tool use, and suggested that different wear patterns were related to cultural differences in tool use and food preparation techniques (Molnar 1971b). These correlations were demonstrated by a cross-cultural comparison of wear types in three North American Indian groups, in which different and unique wear types were related to cultural differences in diet, food preparation methods, and technological activities (Molnar 1971a). Molnar also presented a comprehensive survey of dental wear types among various cultural groups including the Eskimo, South American Indians, North American Indians, and Australian Aborigines, which further confirmed that varying use of teeth as tools caused noticeable differences in the type and degree of wear observed (Molnar 1972). This study also emphasized the value of ethnographic accounts that describe the use of teeth as tools for the interpretation of dental wear patterns (Molnar 1972).

Following Molnar's work, there was an increase in the number of studies on occupational tooth wear, including one account of masticatory and non-masticatory tooth use and wear that presented tobacco or quid chewing, stripping bark, and sharpening sticks or stone tools as activities that could cause distinct wear patterns (Barrett 1977). Subsequent studies also began to recognize and investigate particular forms of tooth wear and their causes, some of which are outlined below:

Chipping

Dental chipping has been examined among Aleuts, Eskimos, and northern Indians (Turner and Cadien 1969), Illinois Indians (Milner 1984), pre-Iroquoian and Iroquoian groups in northern Ontario (Patterson 1984, 1986), and a Neolithic Portuguese sample (Duarte 1993). This type of wear, also known as "pressure-chipping" (Turner and Cadien 1969:303) is generally observed on the anterior teeth. Differences between groups and changes over time have been related both to particulars in diet and the use of teeth as tools. For example, Turner and Cadien (1969) noted that there was a higher degree of chipping in the Eskimos than in the Aleuts, which they attributed in part to the fact that Eskimos chew bones; a practice which has not been ethnographically identified among the Aleuts. Another possibility is that some cases of anterior dental chipping resulted from the practice of retouching stone tools by biting the flake, an activity that has been recorded among Australian Aborigines (Barrett 1960; Gould 1968; Lukacs and Pastor 1988).

Rounded and Cupped Occlusal Wear

Rounded occlusal wear and cupped occlusal wear on the anterior teeth are two distinct patterns that can be directly related to different subsistence strategies. Oblique rounded wear that leaves behind occlusal crescents of enamel has been identified among teeth from early occupational levels at Tehuacan as well as among Eskimo and Australian groups, and may be related to hunter-gatherer food preparation techniques, including processing activities such as pulling and stripping (Anderson 1965; Hinton 1981). The rounded occlusal wear of these hunter-gatherers can be contrasted to the heavily cupped wear on the anterior teeth among agricultural and semi-agricultural groups of southwestern American Indians (Hinton 1981). This latter wear type may be caused by exceptional masticatory stresses placed on the anterior teeth due to "extensive loss of carious posterior teeth" (Hinton 1981:563).

Labial Surface Wear

Several variations of facial or labial surface wear have been observed in both archaeological and modern groups, which has led researchers to suggest several possible causes. One manifestation of labial wear, described as a smooth polishing of the anterior surface of the tooth, has been identified among archaeological samples from Mehrgarh and Harappa in Pakistan (Lukacs and Pastor 1988). The primary cause of this wear is unknown, but it has been suggested that holding a bow drill mouthpiece, or the "stuff and cut" method of meat eating may have been etiological factors (Lukacs and Pastor 1988).

The "stuff and cut" method of eating, in which a piece of meat is held between the front teeth and a knife is used to slice off bites, has also been proposed as an explanation for a very different type of labial wear. This second type of wear, which has been observed among Neandertal remains from sites in France, Switzerland, and Iraq, appears as diagonal striations on the upper and lower anterior teeth and may be the result of a knife blade scratching against the teeth (Bermudez de Castro et al. 1988).

A third type of wear that has been observed on the facial surfaces of the teeth is cervical abrasion, which often appears as wedge-shaped notches in the neck region of the anterior teeth. These lesions are generally believed to be caused by excessive toothbrushing with an abrasive dentifrice (Barrett 1977; Davies 1963; Milner and Larsen 1991; Pindborg 1970; Powers and Koran 1973). One case of cervical wear in historical times was presented in an account of the dental condition of King Christian the Third of Denmark and Norway: both macroscopic and microscopic methods of examination were used to determine that wear was due to the use of a fine abrasive to clean the teeth (Pederson 1979).

Clinical literature has presented findings which can be used to supplement these explanations of cervical lesions. It has been suggested that tensile stress exerted on the teeth through mastication and malocclusion may be a factor, as it can disrupt the chemical bonds between enamel rods. This disruption allows small molecules to enter between the hydroxyapatite crystals, which prevents a re-establishment of the bonds, rendering the teeth more susceptible to dissolution from factors such as toothbrushing or an acidic oral environment (Grippo 1992; Lee and Eakle 1984).

Lingual Surface Wear

Lingual surface wear of the maxillary anterior teeth is one of the more recently observed forms of occupational tooth wear. Three distinct variations of this wear have been recorded, each with its own possible causes. Lingual wear of the maxillary anterior teeth (abbreviated as LSAMAT) was the first kind of lingual abrasion to be identified (Turner and Machado 1983). It is represented in the dentitions of an archaic Brazilian skeletal population and a prehistoric Panamanian group, both of which exhibit pronounced wear on the maxillary teeth with no corresponding mandibular wear. This pattern may be the result of using the upper teeth and tongue to peel or shred grit-laden plants like manioc or tule roots (Irish and Turner 1987; Turner and Machado 1983).

Two additional types of lingual surface abrasion have been recorded among skeletal samples from prehistoric Pakistan (Lukacs and Pastor 1988). One appears as wear of the lingual maxillary incisors associated with labial abrasion and rounding of the lower teeth, and has been attributed to the pulling of material such as animal skin through the teeth (Lukacs and Pastor 1988). The other manifestation of lingual wear is characterized by v-shaped grooves on the maxillary incisors that fit together with the incisal edge of the lower teeth. This wear has not been attributed to a specific activity, although it is hypothesized that using the teeth to clamp an unspecified substance could cause lingual abrasion of this variety (Lukacs and Pastor 1988).

Incisal Grooving of the Anterior Teeth

Incisal grooving of the anterior teeth has been documented among numerous groups, including the Eskimo (Pederson 1952); Tsimshian area Indians of British Columbia (Cybulski 1974); prehistoric California Indians (Schulz 1977); Cherokee Indians (Owsley and Bellande 1982); and hunter-gatherers in the Western Great Basin (Larsen 1985). In each of these cases the grooving appears more often on the mandibular than the maxillary teeth, and tends to run in angles. It is generally agreed that the grooves are the result of fibrous materials being drawn transversely across or through the teeth (Cybulski 1974; Larsen 1985; Owsley and Bellande 1982; Pederson 1952; Schulz 1977). A number of fibrous materials, including sinew (Cybulski 1974; Pederson 1952) and vegetable fibres (Larsen 1985; Schulz 1977) could be processed in this manner, depending on the cultural and technological practices of different groups.

Interproximal Grooving

One of the most widely observed (and widely debated) types of non-masticatory tooth wear is interproximal grooving. This type of wear generally appears as grooves or channels near the cemento-enamel junction on the proximal faces of adjacent teeth (Ubelaker et al. 1969). Interproximal grooving has been recorded among prehistoric and modern peoples from areas all over the world, including North America (Berryman et al. 1979; Owsley and Bellande 1982; Schulz 1977; Ubelaker et al. 1969), North Africa (Bermudez de Castro and Perez 1986), Australia (Brown and Molnar 1990; Frayer 1991), Pakistan (Lukacs and Pastor 1988), and Europe (Formicola 1988; Frayer 1991; Perez et al. 1982).

Several theories have been advanced to explain the etiology of interproximal grooving. Most researchers have agreed that the grooving is probably the result of the insertion of a foreign object between the teeth. There is less consensus with regard to exactly what was used or why. It has been noted that interproximal grooves are often associated with interproximal caries and alveolar bone resorption. This correlation has led many researchers to the conclusion that the grooving is the result of therapeutic or palliative probing with a toothpick or other similar object (Alt and Kockapan 1993; Bermudez de Castro and Perez 1986; Berryman et al. 1979; Frayer 1991; Ubelaker et al. 1969).

Interproximal grooving has not, however, always been found in association with carious teeth, an observation which has led to alternative explanations. One of these explanations is a variation on the toothpick theory, and states that although the use of a toothpick or similar object may have caused the grooves, the activity may have been simply habitual rather than therapeutic (Formicola 1988). Another suggestion is that an occupational activity such as drawing fibrous material through the posterior teeth caused the grooves (Brown and Molnar 1990; Lukacs and Pastor 1988).

Other theories to explain non-carious grooves include Brothwell's (1963) suggestion that the grooves were the natural result of localized ante-mortem erosion, and Wallace's (1974) proposal that the grooves were the result of the forcing of grit-laden saliva through the interdental spaces while swallowing.

<u>Advances in Wear Analysis: Scanning Electron Microscopy</u>

The microscopic examination of dental wear is a valuable analytical tool, because it provides direct evidence of how different behavioral patterns affect the teeth. Scanning electron microscopy (or SEM) has proved to be particularly useful, due to its capacity to produce images of abraded teeth that are up to 100,000 times the original size (Hayat 1978; Hoffman et al. 1968). Much of the research on dental microwear has been conducted on nonhuman primate teeth in order to learn more about their dietary habits (e.g. Gordon 1982, 1984; Kay 1987; Ryan 1979a, 1979b, Teaford 1991; Walker et al. 1978). More recently, however, an increasing number of researchers have used SEM techniques to examine and interpret wear patterns found on the teeth of humans and human ancestors (e.g. Alt and Kockapan 1993; Bermudez de Castro et al. 1988; Bullington 1991; Grine and Kay 1988; Larsen 1985; Lukacs and Pastor 1988; Maas 1989; Parsche 1993; Pederson 1979; Puech and Cianfarani 1988; Puech and Leek 1986; Rose and Harmon 1986; Teaford 1988). In these studies, minute striations have been magnified and examined to determine directionality, depth, and appearance of the abrasion, which may in turn help determine possible causes. This information is of great value for interpretive purposes, for it allows researchers to relate subtle differences in microwear to differences in diet and behavioral patterns.

CONCLUSION

The study of dental wear has, in the last few decades, expanded to include an ever-increasing emphasis on non-masticatory forms of tooth wear, which has greatly aided our understanding of past human behavior. One important development in the interpretation of these wear patterns has been the use of ethnographic information to supplement archaeological data. Use of this technique has allowed researchers to speculate, with some degree of confidence, about the etiological factors involved in non-masticatory dental wear. The incorporation of scanning electron microscopy has also been an important development in the study of dental abrasion, since it allows researchers to formulate and test new hypotheses. Further development and use of SEM techniques in conjunction with traditional macroscopic and ethnological sources of information should lead to a greater understanding of how occupational tooth wear developed in prehistoric humans and their ancestors.

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CHAPTER 3: AN OVERVIEW OF EGYPTIAN HISTORY AND A DISCUSSION OF THE ARCHAEOLOGICAL SITE OF MENDES

INTRODUCTION

The character and development of ancient Egyptian civilization has been largely determined by its isolated desert location and its varying internal geography. Egypt is bordered by the Mediterranean to the north, by the First Cataract of the Nile to the south, and by desert on both the east and west (Figure 3.1). Although these desert peripheries were the site of oases that produced crops and mineral resources, the development of Egyptian civilization was principally focused in three basic geographic areas along the Nile. The first of these areas, located in southern (or Upper) Egypt, was the Nile Valley. This region consisted of narrow strips of land stretching along the length of the Nile, made arable (and consequently, habitable) by alluvial deposits from the annual floods (Moorey 1983). Located north-west of the Valley in an area sometimes called Middle Egypt was the Fayum depression, which comprised the second geographic region of importance. It was a region of great fertility, due in part to its proximity to the Nile-fed lake Birket Qarun. This lake was, in ancient times, a focus for settlement, agriculture, and irrigation (Aldred 1984; Baines and Malek 1980). To the north, in the region known as Lower Egypt, lay the third major geographic area: the Delta, which was the broad, fertile region where the Nile divided into several branches that flowed into the sea (Aldred 1984; Baines and Malek 1980). In ancient times the Delta was composed partly of swamp or marshland, and partly of natural basins that flooded seasonally and supported grasses and other vegetation. The seasonal inundation of the Nile also produced layers of alluvial deposits, forming elevated ridges (or "geziras") suitable for settlement (Baines and Malek 1980; Trigger 1983).

One of the largest and best preserved ancient settlements located along the Delta geziras is at the site of Tell el-Rub'a, known in ancient times as Mendes. Recent excavations conducted at this site have revealed that it was continuously occupied from the Predynastic to the Ptolemaic periods, a span of nearly 3,000 years (Landy 1979). This continuous occupation makes Mendes a particularly interesting site for study, because it provides a consecutive record of some of the political, economic, and religious changes that occurred in the Delta. In order to obtain a full understanding of Mendes' role in antiquity, however, it is first necessary to have an understanding of the general progression of events in the whole of Egypt during the relevant periods of occupation at the site: from the earliest settlers to the end of Egyptian autonomy in 30 B.C. (Figure 3.2).

Early Occupations: From the Palaeolithic to the Archaic Periods

Human occupation in Egypt extended back into the Palaeolithic period (c. 700,000 - 5,500 B.C.) (Hoffman 1979), when people first populated the Nile Valley as small nomadic hunting-gathering-fishing groups (Adams 1988; Moorey 1983). Sites such as Kom Ombo and El Kab in Upper Egypt reveal that by the Late Palaeolithic (c. 15,000 B.C.) there was a technological development of several different lithic industries, including the production of microliths (Hoffman 1979). This technological ability allowed the Palaeolithic peoples to increase their basic food supply to include fish, molluscs, birds, and wild cereals, which consequently permitted increases in population size and induced cultural change (Arkell 1975).

Cultural and economic change were most certainly primary features of the Neolithic (c. 5,500 - 4,000 B.C.) and Predynastic (c. 4,000 - 3,200 B.C.) periods that followed the Palaeolithic. It was during these periods that the areas of Upper and Lower Egypt diverged in their courses of development to produce very different and distinctive cultures.

The Delta and the Fayum appear to have been the centre of development during the Neolithic. Several archaeological sites have been located in these regions, dating back to approximately the sixth millennium BC (Hassan 1988). The relative accessibility to foreigners of these northern regions (as compared to southern Egypt) made them much more susceptible to influences from the Sahara, the Levant, and Southwest Asia. The introduction from Southwest Asia of domesticated cereals such as wheat and barley, and of animals such as sheep and goats, helped to lay the foundation for an agrarian society in Egypt (Hassan 1988; Hoffman 1979; Wenke 1989). The earliest extensive evidence of agricultural practices in ancient Egypt came from Fayum sites such as Kom W (c. 4,700 B.C.) and Delta sites such as Merimde Beni-Salame (c. 4,800 B.C.) (Hassan 1988; Hoffman 1979; Wenke 1989). Archaeological evidence from these areas has provided us with much information about life during the Neolithic. In the Fayum, people employed a mixed subsistence strategy that relied upon agricultural resources such as domesticated plants and animals as well as their traditional hunting-fishing-gathering practices (Wenke 1989). Settlement varied from large sites where year-round habitation was the norm to many small seasonally occupied sites (Hassan 1988). In the Delta, settlements were comprised of small, single-family oval huts. Implements of bone, ivory, and horn, harpoons and fish hooks found in early occupational layers all indicate a continued reliance upon traditional methods of subsistence. However, later occupational layers at Merimde also revealed granaries and other storage bins in the floors of the dwellings, which had themselves become larger and more permanent. These findings indicate the increasing importance of agriculture as a subsistence strategy for the people in these settlements, as well as the presence of a certain degree of community organization (Hassan 1988; Wenke 1989).

Pottery also appeared as a component of the Neolithic period, although it was relatively plain and utilitarian in nature (Hoffman 1979). Burial practices in Merimde and other contemporary sites were simple and showed little social stratification: the dead were usually interred within the villages, along with meagre grave goods (Hassan 1988; Wenke 1989). Other archaeological sites that reveal further information on the development of northern Egypt and its rising prominence during the Predynastic include the el-Omari settlements, which were roughly contemporaneous with the later occupational levels of Merimde. These settlements showed the beginnings of a socially stratified system, illustrated by more elaborate burial practices, increased grave goods and the separation of the cemeteries from the villages. The Delta site of Maadi (c. 3,650 B.C.), is another valuable source, for it shows evidence of being part of a wide trade network (Hassan 1988; Hoffman 1979; Wenke 1989).

The sequence of development in Upper Egypt has been somewhat more clearly defined, largely through the use of pottery seriation techniques. The earliest Neolithic/Predynastic sites in Upper Egypt belong to a culture called the Badarian. The Badarian culture was first identified by Brunton during his excavations in the Badari region of Middle Egypt, and later was confirmed by Caton-Thompson's excavations at Hemamieh (Hoffman 1979). The Badarian culture has been dated to approximately 5,000 B.C. (roughly contemporaneous with the early Fayum and Merimde occupations of Lower Egypt) (Adams 1988; Hoffman 1979). Badarian people, in contrast to preceding Palaeolithic and Epipalaeolithic people, belonged to a largely sedentary farming and herding society. Archaeological evidence has shown that Badarian technology included a flint-working industry that relied mainly upon the use of cores for tools, as well as some copper working. The Badarians also displayed a sophisticated pottery industry that produced a distinctive rippled style. One feature which particularly distinguished the Badarians as different from their contemporaries in Lower Egypt was their more elaborate burial practices, which incorporated a standardized interment position, oval-shaped graves, and numerous offerings (Adams 1988; Trigger 1983).

The next phase in the Predynastic development of Upper Egypt is called the Amratian (or Nagada I) period. This period, which has been illustrated by sites at Hierakonpolis, Nagada, and Hemamieh, dates from approximately 4,000 - 3,500 B.C. (Adams 1988; Hassan 1988; Trigger 1983). Amratian sites were generally larger and more prosperous than Badarian ones, although both traditions relied upon similar subsistence economies. Dwellings appear to have been of a semi-permanent nature similar to those of the Badarian, with mud or clay foundations and wattle and daub superstructures (Arkell and Ucko 1965). The main differences between the Amratian and the Badarian can be seen in the change of stone tool technology, which evolved from a simple core industry to a mainly bifacial style with ground and flaked edges (Arkell and Ucko 1965; Trigger 1983). The beginnings of a stone-working tradition have also been observed, and pottery styles, while showing some links to the previous Badarian tradition, were mainly characterized by a decorated style called "white cross-lined" (Arkell and Ucko 1965). Amratian burials were basically similar to those of the Badarian, with perhaps a slight increase in grave size and number of offerings (Adams 1988).

It was during the following Gerzean (or Nagada II) period (c. 3,500 - 3,150 B.C.) that the most rapid changes of the Predynastic age occurred (Trigger 1983). Gerzean occupations, which have been located at Hierakonpolis, Hemamieh, and Nagada, were much more widespread than Amratian sites, extending from the border of Lower Egypt to the middle of Lower Nubia (Arkell 1975). Artifact assemblages included sophisticated flint blades, numerous copper artifacts, and evidence of gold and silver. This expansion of artifact types, along with new decorated and wavy-handled pottery styles, is indicative of foreign influences due to contact and trade (Trigger 1983). Traditional hunting and gathering practices declined and agriculture became the primary mode of subsistence, with evidence of barley and wheat cultivation, as well as the raising of pigs, sheep, goats, and cattle (Hassan 1988). Gerzean dwellings also showed a departure from earlier Predynastic styles, with the introduction of rectangular mud-brick houses. Increased grave size, a distinct pattern of disposal of grave goods, and an increased number of burials from the cemeteries of this period revealed that both population size and degree of social stratification had been expanding (Adams 1988; Arkell 1975; Arkell and Ucko 1965; Trigger 1983). These changes all indicate that by the end of the Predynastic, Egypt had developed a powerful economy and complex hierarchical social and political institutions (Wenke 1989).

Pharaonic Rule: From the Old Kingdom to the Third Intermediate Period

The Archaic or Early Dynastic Period, comprised of Dynasties I and II (c. 2,900 - 2,650 BC) was a period of political unification for Upper and Lower Egypt. Most scholars agree that this unification was achieved by Menes, founder of the first Dynasty, who then established a centrally administered government with its capital at Memphis in Upper Egypt (Trigger 1983; Wenke 1991). The Archaic period saw the further evolution of many Predynastic cultural and economic trends. Settlements largely remained as scattered villages and agriculture continued to be the primary form of subsistence. The social and political stratification that had begun during the Predynastic developed into a distinct hierarchy with the king at the top, followed in status by nobles, lesser administrative officials, craftsmen, and peasants. An important addition to the nature of this hierarchy was that for the first time, kings began to claim divine status (Aldred 1965; Trigger 1983). Both this divine status and the hierarchical nature of Archaic society were reflected by the funerary customs of the time. Cemeteries excavated at Saqqara, Abydos, Nagada, and Helwan clearly revealed differences between the royal and upper ranking burials, which were now concealed within mastaba tombs, and the burials of the lower classes, which differed very little from those of the Predynastic (Trigger 1983). The technological capability of the Archaic Egyptians also expanded. Craftsmen began to work full-time for the king on a specialized basis. The production of pottery, flint tools, copper, jewellery, and stone sculpture all demonstrate both the increased demand and the enhanced quality of trade and luxury goods (Aldred 1965; Trigger 1983).

The Old Kingdom (c. 2,650 - 2,180 B.C.) spanned the Third through Sixth Dynasties. Many of the trends that had developed during the Predynastic and Archaic periods were fully realized during the Old Kingdom. Egypt was now a well-developed complex nation state that enjoyed unity, stability, expansion and prosperity. The central administrative authority remained at Memphis, and although urban areas such as Hierakonpolis and Abydos, pyramid towns such as Giza and Abusir, and trading centres such as Elephantine and Buhen did exist, the majority of Egypt's population still resided in small provincial villages, many of which were located in the Delta (Baines and Malek 1980; Kemp 1983; Wenke 1989, 1990, 1991). The predominance of villages in the Delta was likely the result of two trends: the growing importance of foreign relations and trade; and the increased utilization of the Delta's vast agricultural potential. Agriculture was not, however, the most important industry of the Old Kingdom. Instead, the construction and equipping of funerary monuments was the focus of pharaonic civilization. This practice was directly related to the most significant feature of Old Kingdom society: divine kingship and the rise of the pharaonic cult (Aldred 1984; Kemp 1983). The divine nature of the king became the cornerstone of Egyptian religion, which was developing its own complex pantheon complete with detailed myths and rituals. Of these rituals, the practice of mummification before burial is perhaps the most well known. The study of burial practices such as this as well as the excavation of cemetery complexes has provided us with much of the information we have about the Old Kingdom. Some of the most famous funerary monuments of ancient Egypt were constructed during this period, which is also known as the Pyramid Age. The construction of pyramid tombs for the rulers of the Third through Sixth Dynasties is first evidenced by the Step Pyramid of Djoser at Saqqara. The most impressive of the pyramid monuments, however, are found at the Giza complex, which was comprised of three enormous pyramids constructed for the Fourth Dynasty rulers Cheops, Chephren, and Menkaure (Aldred 1965; Aldred 1984; Moorey 1983). By the Fifth Dynasty, pyramid funerary monuments were being built on a smaller scale. This decrease in scale is believed to reflect a decrease in both the power and prestige of the pharaoh. At the same time, provincial governments and local nobility were exerting more control over Egyptian affairs. The increasingly feudal character of the Egyptian state, combined with climatic change and the development of famine conditions, finally culminated in the collapse of the Old Kingdom after the reign of the Sixth Dynasty pharaoh, Pepy II

(Aldred 1984; Grimal 1988).

The following First Intermediate Period (c. 2,180 - 2,050 B.C.) was a time of instability, famine, and political insecurity (Bell 1971; Butzer 1984; Kemp 1983). Rivalries between local governors caused much civil strife, and there was a rapid succession of rulers during the Seventh and Eighth Dynasties. At this time Egypt also had to contend with the infiltration of foreigners, particularly in the Delta region. The Ninth and Tenth Dynasties, which were based in the Middle Egyptian city of Herakleopolis, succeeded in expelling the Asiatic invaders and fortifying Egypt's eastern borders. The Herakleopolitans, however, clashed with the rival Eleventh Dynasty of Thebes and were eventually defeated by Nebhepetre Mentuhotep II, who reunited Egypt and founded the Middle Kingdom (Aldred 1984; Grimal 1988). Interestingly, the difficult times of famine and strife which characterized the First Intermediate Period did not result in a decline in cultural achievement. Instead, this period saw the development of numerous literary works, the beginnings of the cult of Osiris, and innovations in art and sculpture (Grimal 1988).

The Middle Kingdom (c. 2,050 - 1,800 B.C.) saw a return to the stability and prosperity that had characterized the Old Kingdom. The Twelfth Dynasty succeeded in reestablishing the authority of a central government under the pharaoh. The capital was moved from Thebes to a site near Memphis called It-tawi, and rulers were buried in pyramids at Lisht, Lahun, Dahshur, and Hawara (Baines and Malek 1980; Moorey 1983). Egypt became active in trade once again, establishing exchange with Palestine, Syria, Sinai, and Crete. Military campaigns asserted Egyptian authority over Nubia, as far south as the Second Cataract (Baines and Malek 1980). Cultural achievements continued to flourish, exhibiting links to the past as well as new innovations. Art and sculpture were largely reminiscent of Old Kingdom styles, but the new proliferation of funerary models depicting houses, bakeries, boating, and other everyday activities has provided us with some of the best documentation of daily life in ancient Egypt (Moorey 1983). Literature was at its classical best, and much of what was produced during the Middle Kingdom remained unrivalled in quality throughout the rest of Egyptian civilization (Grimal 1988; Moorey 1983). Numerous important building projects were also undertaken during this period, including funerary complexes, dykes, and drainage canals. Associated with these projects were workmen's towns and villages such as the site of Kahun, which has revealed information on domestic architecture and town planning (Grimal 1988; Kemp 1989).

The processes which caused the breakdown of the Middle Kingdom and the onset of the Second Intermediate Period (c. 1,700 - 1,570 B.C.) were similar to those that had signalled the end of the Old Kingdom. A persistent migration of Asiatics into Egypt (and especially into the Delta) resulted in the reestablishment of regional centres of authority. This increased provincial authority, combined with weakening pharaonic power, eventually brought about the second collapse of Egypt's centralized government (Baines and Malek 1980; Grimal 1988; Moorey 1983). Little is known about the Thirteenth and Fourteenth Dynasties, except for the fact that they may have ruled concurrently from different capitals. Meanwhile, foreign Asiatics called the Hyksos infiltrated into the Delta region and established the Fifteenth and Sixteenth Dynasties, which were based in the new capital of Avaris in the eastern Delta. By 1,674 B.C., the Hyksos had extended their authority far enough south to capture Memphis, and proceeded to adopt all of the trappings of Egyptian royalty including titles, costumes and traditions (Aldred 1984; Moorey 1983; Wenke 1990). The influence of the Hyksos rulers did not, however, extend over all of Egypt. The Seventeenth Dynasty of Thebes was ruling simultaneously in Upper Egypt, extending their influence from Elephantine to Abydos. These dual dynasties continued to operate semi-independently until the Hyksos were driven out by the Theban king Ahmose, who succeeded in liberating Egypt from foreign domination, reestablishing its links with the Middle East, and generally laying the foundations for the powerful New Kingdom empire which was to follow (Grimal 1988).

The New Kingdom (c. 1,570 - 1,080 BC) was a period of enormous prosperity for Egypt. During the Eighteenth Dynasty the system of government was reorganized to replace the ad-hoc provincial governments with a strong centralized administration. The king was once again the most powerful figure, although most of the administrative tasks were carried out by civil officials and viziers (Moorey 1983; O'Connor 1983). Egypt carried out a campaign of foreign expansion and trade that ensured its authority over Nubia and Kush and established political and trade contacts with the peoples of the Aegean, the Near East, and North Africa. These contacts immeasurably enriched the Egyptian economy through the import of slaves, raw materials, and manufactured goods (Moorey 1983; O'Connor 1983; Wenke 1990). This affluence was reflected in the art and architecture of the period. Many new building projects were undertaken, notably the great temple of Karnak at Thebes and the royal tombs in the Valley of the Kings. Other famous building projects that were undertaken in the New Kingdom occurred during the reign of the Eighteenth Dynasty pharaoh Akhenaten. Akhenaten, who introduced a monotheistic religion based upon worship of the god Amon-Re, constructed a new state capital at Tell el-Amarna, complete with impressive temples and administrative buildings. Both Akhenaten's religion and his capital were abandoned soon after his death, however, and traditional religious views were restored under Smenkhare and then Tutankhamun, whose opulent tomb made him perhaps the most famous of all the pharaohs (O'Connor 1983; Wenke 1990). Extensive building projects continued into the Nineteenth Dynasty with the reign of Ramesses II, who constructed numerous buildings and temples, the most famous of which is at Abu Simbel. However, the stability of the New Kingdom began to decrease somewhat as the power and authority of the pharaoh declined towards the late Nineteenth and early Twentieth Dynasties. Egypt lost its dominance over Nubia and once again began splitting into a feudal society where the power increasingly lay with the priesthood and the military colonists (Baines and Malek

1980). During the reign of Ramesses III, Egypt began to lose its Asiatic conquests and had to repulse attempted invasions by the "Sea Peoples" and the Libyans. Soon after the death of Ramesses XI, the last ruler of the Twentieth Dynasty, Egypt reverted to a division of power between the north and the south (Grimal 1988).

This division of power characterized the early part of the Third Intermediate Period (c. 1,080 - 712 B.C.). The Twenty-first Dynasty ruled Lower Egypt from Tanis, while Upper Egypt was controlled by the priesthood of Amun at Thebes. The co-existence of these two groups continued for a peaceful century. The Twenty-second to the mid-Twenty-fifth Dynasties, however, were characterized by competing rulers, tensions over regional independence, and extreme political fragmentation. During this period Memphis and Thebes declined in importance, and cities such as Tanis in the Delta region rose to prominence (O'Connor 1983).

The Late Period and the Ptolemaic

The Late Period (c. 712 - 322 B.C.) saw Egypt functioning as an independent political entity for the last time (Lloyd 1983). The period began when Twenty-fifth Dynasty Nubian rulers from the Kingdom of Kush (the Kushites) eliminated other competing kings and initiated a new period of unity and stability. The Kushite kings advocated a return in tradition to the days of the Middle and New Kingdoms, as seen by the revival of classical styles of art and architecture. The authority of the Kushites, however, was eventually usurped by the Sais-based rulers of the Twenty-sixth Dynasty (the Saites), who carried Egypt through its last great period of native rule (Aldred 1984; Moorey 1983). The Saites extended their domination of the increasingly important Delta region to include Middle and Upper Egypt and then continued to expand abroad. Egypt's foreign involvement grew with the establishment of trade relations with Greece, Phoenecia, Palestine and Syria (Lloyd 1983; Moorey 1983). Daily life in Egypt appeared to function on much the same pattern it had in the past. The economy was still largely based upon local and foreign exchange, agriculture, and animal husbandry. Settlements remained similar to earlier periods in type and size, consisting of national capitals such as Memphis and Sais, provincial administrative centres such as Mendes and Bubastis, and small local towns built on mounds or geziras. Religion also was basically unchanged, except for the notable rise in prominence of animal cults such as that of the cat-goddess Bast of Bubastis and the Ram cult at Mendes (Aldred 1984; Lloyd 1983). This state of affairs generally continued even after Saite rule ended with the invasion of the Persians, who dominated Egypt for nearly two centuries. The Persians were neither welcomed nor liked by the Egyptians, who, through a series of revolts, managed to regain their liberty from approximately 404 - 343 B.C. This brief independence was quashed by the second period of Persian domination, which lasted from 343 B.C. until the Macedonian conquest of 322 B.C. (Baines and Malek 1980; Lloyd 1983).

Egypt was released from Persian domination by Alexander the Great, who entered Egypt in 322 B.C. After Alexander's death, Egypt was ruled by General Ptolemy and then by his descendants (the Ptolemies) until 30 B.C., when the country fell under the domination of Rome. The early Ptolemaic period was one of great progress, for that was the time when Egypt became fully incorporated into the Mediterranean world. A new capital called Alexandria was constructed at the extreme northwest edge of the Delta, intensifying that area's importance as never before. Mediterranean immigrants poured into the Delta and the Fayum, which resulted in significant development of both the number of towns in these regions and their importance as economic, administrative, and cultural centres (Bowman 1986). Agricultural innovations were also introduced, including crop rotation, improved irrigation practices, and large-scale land cultivation in the Fayum (Baines and Malek 1980). Egyptian religion maintained its traditions under the Ptolemies. Numerous monuments, temples and shrines were built both at major sites such as Luxor in Upper Egypt and in smaller villages in the Fayum. The practice of mummification continued, and several examples of this practice have been recovered ranging from the simple bandaged mummies of the poor to the elaborately decorated coffins and tombs of the rich (Bowman 1986).

Mendes: Its History, Setting, and Archaeology

History

Several town sites have been identified in the Delta. Of these, Mendes is one of the largest and best preserved. Evidence from archaeological and literary sources such as ceramic styles, grave goods, and inscriptions, indicate that the site, which in later times functioned as both a cult centre and an administrative capital, was continuously occupied from the Predynastic to the Ptolemaic periods (Brewer and Wenke 1992; Landy 1979; Redford 1988; Wilson 1982). Inscriptions in the tombs of local priests made reference to the site as early as the First Dynasty, although the name Mendes itself began appearing in inscriptions from the Fourth, Fifth and Sixth Dynasties, which is believed to have been a time of great prosperity for the town (Wilson 1982). Evidence also shows an early (Fourth Dynasty) appearance of the Ram cult, which remained significant throughout Mendes' history (Redford 1988). The following First Intermediate and Middle Kingdom periods suffer from a lack of representation in the archaeological record, but inscriptional evidence has indicated that Mendes remained prominent during this time. The role of Mendes in the Second Intermediate Period and the effects of the Hyksos occupation in this area are, unfortunately, unknown (Redford 1988).

From the Eighteenth Dynasty on, Mendes appears to have renewed its importance both as a cult centre and an administrative capital. This prominence continued through the later phases of Egypt's history, particularly during the Late and Ptolemaic Periods. During these periods some of the most notable events in Mendes' history occurred, such as the construction of the four great Naoi; the establishment of the Twenty-ninth Dynasty, the pharaoh of which ruled for approximately twenty years; and the construction of the stela of Ptolemy II at Tell el-Rub'a (Baines and Malek 1980; Redford 1988). This great period of achievement ended with the Roman occupation of Egypt, when the site was abandoned after nearly 3,000 years and the community shifted to the southern mound of Tell Timai (ancient Thmuis) (Redford 1988).

The Site and its Surroundings

Settlement at Mendes took place on a mound located on the Mendesian branch of the Nile. This tributary is believed to have formed the natural division between the two mounds of the site: Tell el-Rub'a to the north and Tell Timai to the south (Holz 1980; Redford 1988). Although today climatically Mendes is classified as a desert region, the ancient city was actually part of a well-watered region with an abundance of plant and animal life (Holz 1980).

The mound of Tell el-Rub'a, which is in part delineated by mudbrick enclosure walls, has a perimeter of approximately 5.5 kilometres (Hansen and Stieglitz 1980). Four basic parts of the mound have been identified: the temple precinct, where the one remaining great granite Naos and the temple foundations are located; the northern tip of the kom, which shows evidence of mudbrick buildings; Tell el-Izam (also known as Kom el-Adhem), a cemetery mound located east of the enclosure wall; and the Southern Mound, where the remains of public buildings have been found (Hansen and Stieglitz 1980; Lovell, in press).

The earliest excavations at Mendes were conducted at Tell el-Izam in 1947 by Labib Habachi, who revealed numerous poorly preserved disturbed burials in this area. He also discovered heaps of burned animal bones and ram horns accompanied by amulets. Habachi believed that the amulets had been placed on the bodies of the animals before burial, and concluded that Tell el-Izam had been in use during the Late Period and that sacred animals were buried nearby (De Meulenaere 1976).

Archaeological Research: Past and Present

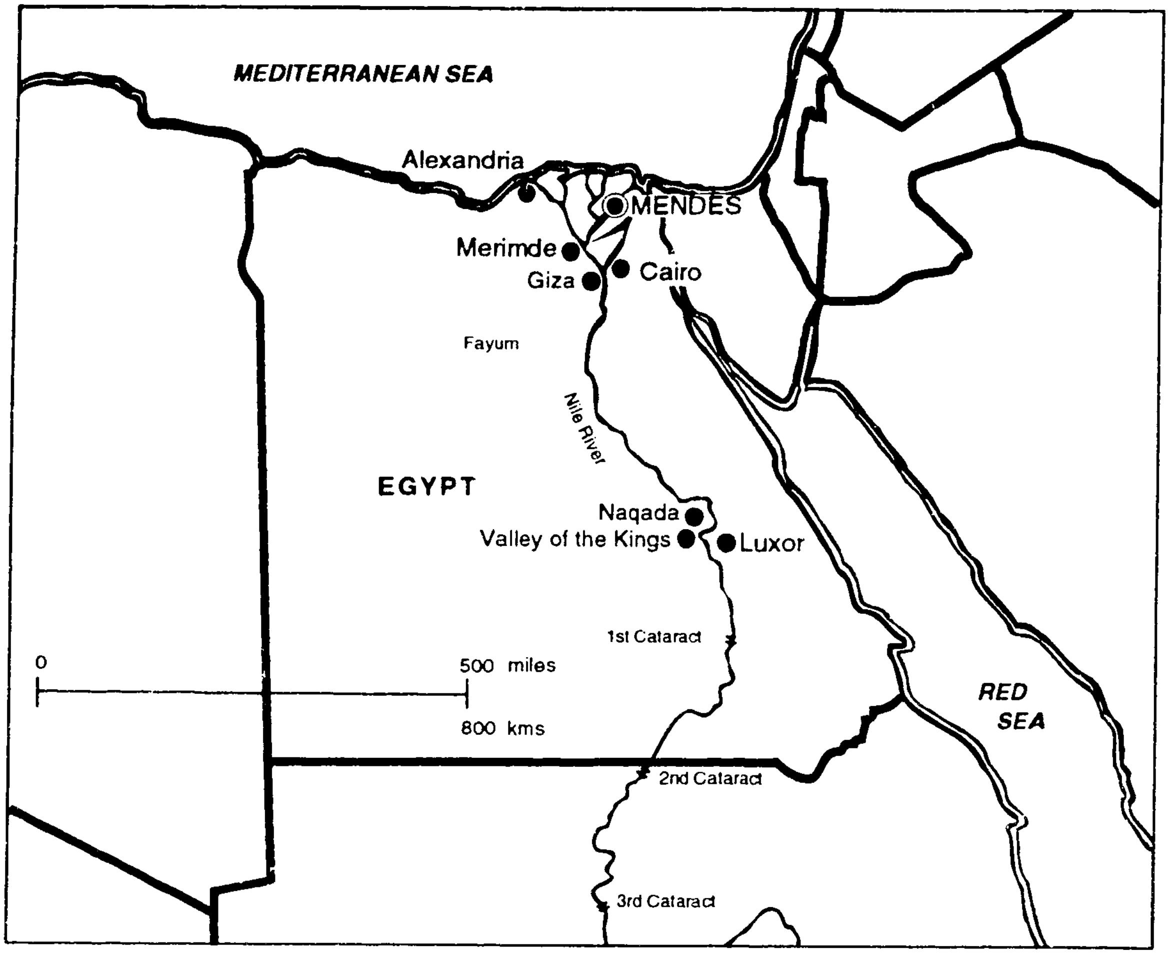
During the field seasons of 1964 - 1966 and 1976 - 1978, Donald P. Hansen of the Institute of Fine Arts at New York University conducted the first systematic excavations of the great Naos of the Twenty-sixth Dynasty at Tell el-Rub'a, revealing that not one but four great Naoi existed; dedicated to the gods Geb, Ra, Shu, and Osiris, respectively. In addition, the excavations revealed deposition layers that dated to the Archaic, Old Kingdom and First Intermediate Periods. These layers yielded both occupational levels and skeletal remains (Hansen 1967; Landy 1979). In 1979 and 1980, excavations directed by Bernard V. Bothmer, Donald P. Hansen and Karen Wilson explored the Third Intermediate Period and Late Period levels of the site (Wilson 1982).

Since 1990, Tell el-Rub'a has been investigated by a number of researchers. Douglas Brewer and Robert Wenke, who excavated during the 1990 - 1992 field seasons, explored the Predynastic, Archaic and Old Kingdom levels located to the northwest and northeast of the standing Naos (Brewer and Wenke 1992). Concurrent investigations included Donald Redford's exploration of the areas southwest of the great Naos, which contain occupational levels from the Middle Kingdom, Second Intermediate, and Late Periods (Redford 1988); and Nancy Lovell's excavations of Ptolemaic burials at Kom el-Adhem in 1992 (Lovell, in press).

CONCLUSION

The development of Egyptian civilization has been largely determined by its isolated desert location and its varying internal geography. Although many of the most famous ancient cities and monuments of ancient Egypt are located in the southern region (also known as Upper Egypt), literary and archaeological sources indicate that the Delta also played a prominent role in the formation and advancement of ancient Egypt. The fertility of the region, combined with its accessibility to foreigners, made the Delta a centre of economic, administrative, and cultural development. Archaeological research at sites such as Mendes further serve to illustrate the important role the Delta played in antiquity, by providing us with new information about the religion, settlements, and daily lives of the ancient Egyptians.

Figure 3.1. Map of Egypt, showing Mendes and some additional sites that were important during the development of Egyptian civilization.



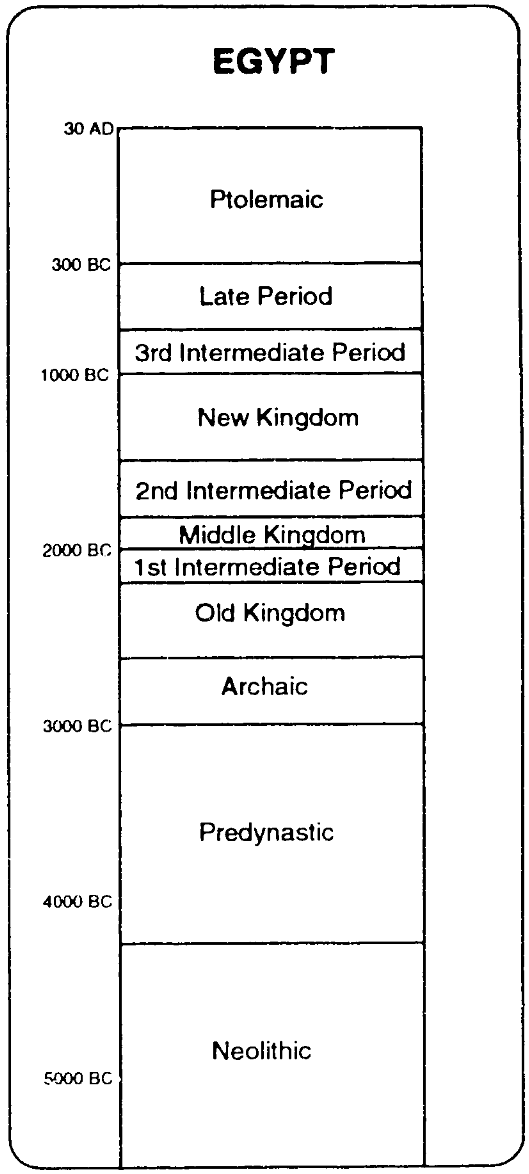


Figure 3.2. Chronology of Egypt, to the end of the Ptolemaic Period.

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CHAPTER 4: MATERIALS AND METHODS

During the 1976-1978 excavations at Tell el-Rub'a, under the direction of Donald P. Hansen and the Institute of Fine Arts at New York University, a total of 73 burials were recovered. Through the use of grave goods, ceramic styles, and inscriptions, these burials were dated to the Old Kingdom, First Intermediate Period/Middle Kingdom, and Ptolemaic periods. Following excavation, the skeletal remains of 53 individuals were shipped to the United States and stored until 1992, when they were brought to the University of Alberta for cataloguing and analysis. During the initial analysis, both the osteological and dental remains were examined, which led to further investigation of the dental wear patterns in the sample.

The majority of the remains were fragmentary in nature, which reduced the certainty of age and sex determination. Sex determination was based upon gross morphological features of the cranium and postcranium after Bass (1987), Ubelaker (1989) and White (1991), and in some cases was supplemented by information taken from the original field notes of the principal excavator, Bonnie Gustav. These methods allowed all but one of the skeletons to be sexed with a good degree of certainty, as presented in Tables 4.1 and 4.2. Age determination was, however, somewhat more difficult. Pubic symphysis aging techniques were not applicable to this sample, as that part of the skeleton was rarely preserved. The predominant method used for age determination of the specimens was through the analysis of ectocranial suture closure, as described by Meindl and Lovejoy (1985). This technique was supplemented in part by examination of dental eruption, particularly of the third molar (Bass 1987). Because of the fragmentary nature of the remains, even these techniques did not, in most cases, allow for the determination of age categories more specific than "Subadult" (under 18 years) and "Adult" (19 years or older). It is for this reason that age breakdowns of the sample are not presented: nine subadult skeletons were excluded from dental wear analysis because in subadults, the full complement of permanent teeth is not in occlusion long enough for distinctive wear patterns to develop. All remaining individuals were classed as "Adult".

Although teeth are generally considered to be one of the best sources of information about archaeological skeletal remains because of their resistance to deterioration after burial (Bass 1987; Duarte 1993), the teeth from the Mendes sample, in contrast, proved to be poorly preserved. This is illustrated by the reduction of the sample by 18 individuals for which no dentition was recovered, as well as by the fact that out of the remaining 26 individuals (and a possible 832 teeth), only 317 teeth (or 38 percent) were sufficiently preserved for examination (see Table 4.3 for a division by tooth class). The poor preservation of the dental remains may be due to a number of factors including burial conditions, (this includes soil type, erosion, humidity, temperature, oxygen, flora and fauna), excavation techniques, and curatorial conditions (Duarte 1993; Henderson 1987). Excavation records for the Mendes skeletal material do not provide detailed accounts of the soil conditions. It is possible, however, that the soil conditions varied from one excavation area to the next, which may have had an effect on the preservation. For example, the dry sand conditions at Kom el-Adhem, where the Ptolemaic burials were excavated, may have resulted in poorer preservation of the skeletal material. This may, in turn, partially account for the smaller number of Ptolemaic burials and teeth in the sample. The excavation records also indicate that in some cases, burials that appeared to be complete in situ were not fully excavated or recovered, which likely accounts for some of the missing dentitions.

Although not all of the material present at the site was recovered, the excavation records do not indicate any preferential bias in the recovery of skeletal material. Selection and preservation of the material was arbitrary and not based upon sex, age, presence or absence of teeth, or unusual dental wear. Therefore, any apparent biases in the sample, such as the low number of male teeth in the Ptolemaic period (Table 4.2), are random and can not be attributed to excavation strategy.

Although the poor preservation and loose condition of the teeth in the sample presented some drawbacks during analysis, including a more complicated identification process and the inability to observe patterns of wear within an individual, the use of isolated teeth also has certain benefits. One such benefit is the ability to observe all aspects of the tooth, including the interproximal surfaces and the root. When the teeth are in situ, these surfaces are usually at least partially obscured, which may prevent certain wear patterns from being recorded. Another advantage in the examination of loose teeth is that they can easily be examined microscopically.

Macroscopic Analysis

One of the difficulties in dental wear studies has been the lack of a standardized methodology for scoring (Milner and Larsen 1991). These difficulties are magnified when the wear being scored is occupational or non-masticatory, as new variations in these forms of wear continue to be reported. Some researchers have attempted to rectify this situation by defining a series of criteria which can be used to identify instances of dental abrasion resulting from tooth-tool use (Blakely and Beck 1984), and by presenting a method of scoring abrasion that is based not only on the amount of wear, but also on the angle of the wear plane (Molnar 1971). The macroscopic examination of the teeth in this study was thus approached with these factors in mind, and attempts were made to establish a relatively simple and easily repeatable method for recording and scoring the wear.

Macroscopic examination of the teeth was conducted over a two-month period between September and October of 1993. With the aid of a ten-power hand lens, each tooth was examined separately, and detailed written descriptions were made of any wear that appeared to have been caused by activities other than normal occlusal forces. These written descriptions were then used to form nine separate wear categories, loosely based upon Molnar's (1971) system of scoring wear planes (see Figure 4.1):

1. Chipping: characterized by the removal of small flakes of enamel from the incisal edge or labial surface of the tooth.
2. Flat Root Wear: characterized by polishing or facet formation on the facial

surface of the root, directly adjacent the cemento-enamel junction.
3. Flat Facial Wear: similar to flat root wear, except the polishing was located on the enamel on the facial surface of the tooth.
4. Flat Cemento-Enamel Junction (CEJ) Wear: facet formation on the facial surface of the tooth at the cemento-enamel junction.
5. Oblique Labial/Buccal Wear: oblique or rounded wear that affected the labial or buccal surface of the tooth only.
6. Oblique Lingual Wear: oblique wear that affected the enamel on the lingual surface of the tooth only.
7. Oblique Mesio/Distal Wear: the occlusal or incisal surface of the tooth was worn to a higher level at the mesial edge than at the distal edge; or vice versa.
8. Interproximal Wear: wear facets that appeared between the teeth on or above the cemento-enamel junction, located closer to the root of the tooth than contact wear facets.
9. Saddle-shaped Wear: wear extending up onto the enamel of both the labial and lingual surfaces.

Each tooth was scored for the presence or absence of these wear types. Although intra-observer error was not specifically assessed, several efforts were made to ensure that the effects of such errors were minimized, including the use of detailed written descriptions and photographic records (utilizing both black and white prints and color slides). In addition, all data collection was conducted under the supervision of Dr. N. Lovell in order to ensure proper identifications and consistency in scoring. The data was then codified into numerical form and entered into Excel on the Macintosh. All entries were verified manually and then imported into Systat (v. 5.2.1). Frequency distributions were calculated, and chi-square analyses (using Yates' correction and Fisher's Exact tests when sample sizes dictated) were conducted in order to detect any patterns in the data, such as whether any significant changes in wear frequencies occurred over time, whether any sex differences were present, and whether there were significant changes within the sexes over the three time periods.

Microscopic Analysis

The dentition of 5MB12, an adult female from the First Intermediate Period/Middle Kingdom, was selected for a more detailed microscopic analysis for two reasons. The first was that examples of all but one of the observed wear patterns in the sample were expressed in the dentition, and the second reason was that all occurrences of flat wear (including facial, root, and CEJ wear) and saddle-shaped wear were limited to this individual. Scanning electron microscopy (SEM) was utilized because it has several benefits, including a depth of focus approximately five hundred times greater than that of a light microscope, the ability to reproduce a three-dimensional image, increased image resolution, and the capacity to produce magnifications up to 100,000 times the original size (Hayat 1978; Hoffman et al. 1968).

Three teeth were selected for detailed study: the first left mandibular molar, representing both oblique buccal wear and flat CEJ wear; the maxillary left lateral incisor, representing flat CEJ wear; and a maxillary central incisor, representing saddle-shaped wear. The central incisor could not be sided because of antemortem wear and postmortem breakage, both of which obliterated many of the characteristic features used for siding. The teeth, which had been originally cleaned by dusting the surfaces with a paintbrush, were cleaned in preparation for the SEM by swabbing them with an ethanol solution in order to remove any residual contamination by dirt or dust particles, as recommended by Hayat (1978); Rose (1983); Ryan (1979); and Shkurkin et al. (1975). In order to prevent specimen damage such as overheating and cracking of the enamel, which may be caused by excessive charging in the SEM, steps were taken to ensure the conductivity of the material. In practice, this can be done either through the use of replication techniques, which have been utilized by several researchers for microwear studies (e.g. Barnes 1978; Bullington 1991; Gordon 1984; Grine and Kay 1988; Kay 1987; Lukacs and Pastor 1988; Rose 1983; Teaford 1988a, 1988b, 1991), or through coating the specimen with an electrically conductive substance (Boyde 1974; Gabriel 1985; Hayat 1978). The latter method was chosen for this analysis for a number of reasons: first because the casting process is a complicated procedure requiring specific equipment, materials, and specialized knowledge; second, because the porous and fragile nature of the samples placed them at risk of damage during the casting process; and third, because image artifacts such as bubbles and foreign particles often appear in the cast and can obscure and distort microwear features (Rose 1983). Coating the specimen with a conductive substance was a viable alternative, because it both reduced the build-up of electric charge on the specimen surface and increased the emission of low-energy secondary electrons, which in turn served to improve image contrast (Boyde 1974; Hayat 1978). Initial coating of one specimen, the maxillary left lateral incisor, was attempted using a liquid organic anti-static agent, a fatty-acid compound manufactured by Ernest F. Fullam Inc. The compound was brushed onto the tooth with a paintbrush, and was quickly absorbed into the porous areas of the tooth (the root and the exposed dentine), although it left a film on the enamel. Unfortunately, excessive charging of the sample surface in initial SEM trials indicated that this form of coating was not sufficient to both yield an acceptable image and prevent heat damage to the tooth. For the remaining SEM analysis, the samples were placed in a Hitachi HUS-4 vacuum evaporator, and a carbon rod was evaporated using resistive heating in order to coat the samples (Heidler, unpublished manuscript). Carbon coating was chosen over the more widely-used gold coating technique mainly because it was believed that carbon would be more easily removed from the tooth than gold, which would be a relatively permanent coating on a tooth (Wayman, pers. comm.).

The SEM analysis was made possible through the courtesy of the Department of Mining, Metallurgy and Petroleum Engineering at the University of Alberta, which provided access to a Hitachi Model S-2700 Scanning Electron Microscope. Each tooth was mounted in the SEM and examined using secondary electron imaging. Secondary electron imaging, which is the most commonly used form of SEM analysis, occurs when the primary beam of electrons from the microscope undergoes inelastic collisions within the sample, thus liberating low-energy secondary electrons from the target area. These secondary electrons are then emitted in all directions from the specimen surface, and are collected in order to reproduce an image of the surface topography of the specimen (Hayat 1978). Polaroid micrographs ranging in magnification from 25 x for overall views to 570 x for detailed images were then taken in order to study various sections of the abraded areas and the associated enamel. In order to compensate for possible obscurement of features caused by the orientation o^c the specimen (Gordon 1988), each area was photographed at a standard orientation and then at a 90 degree rotation. Comparison and quantification of the microwear features from both angles did not reveal an appreciable difference in the amount of features observed (Heidler, unpublished manuscript).

Table 4.1.
Sex Composition of the Skeletal Sample
(Individual Count)

Time Period

Sex	Old Kingdom	FIP*/Middle Kingdom	Ptolemaic	Total
Females	6	3	3	12
Males	6	6	1	13
Unknown	1	0	0	1
Total	13	9	4	26

*Note: FIP = First Intermediate Period.

Table 4.2.
Sex Composition of the Skeletal Sample
(Tooth Count)

Time Period

Sex	Old Kingdom	FIP*/Middle Kingdom	Ptolemaic	Total
Females	65	60	54	179
Males	75	45	4	124
Unknown	14	0	0	14
Total	154	105	58	317

*Note: FIP = First Intermediate Period.

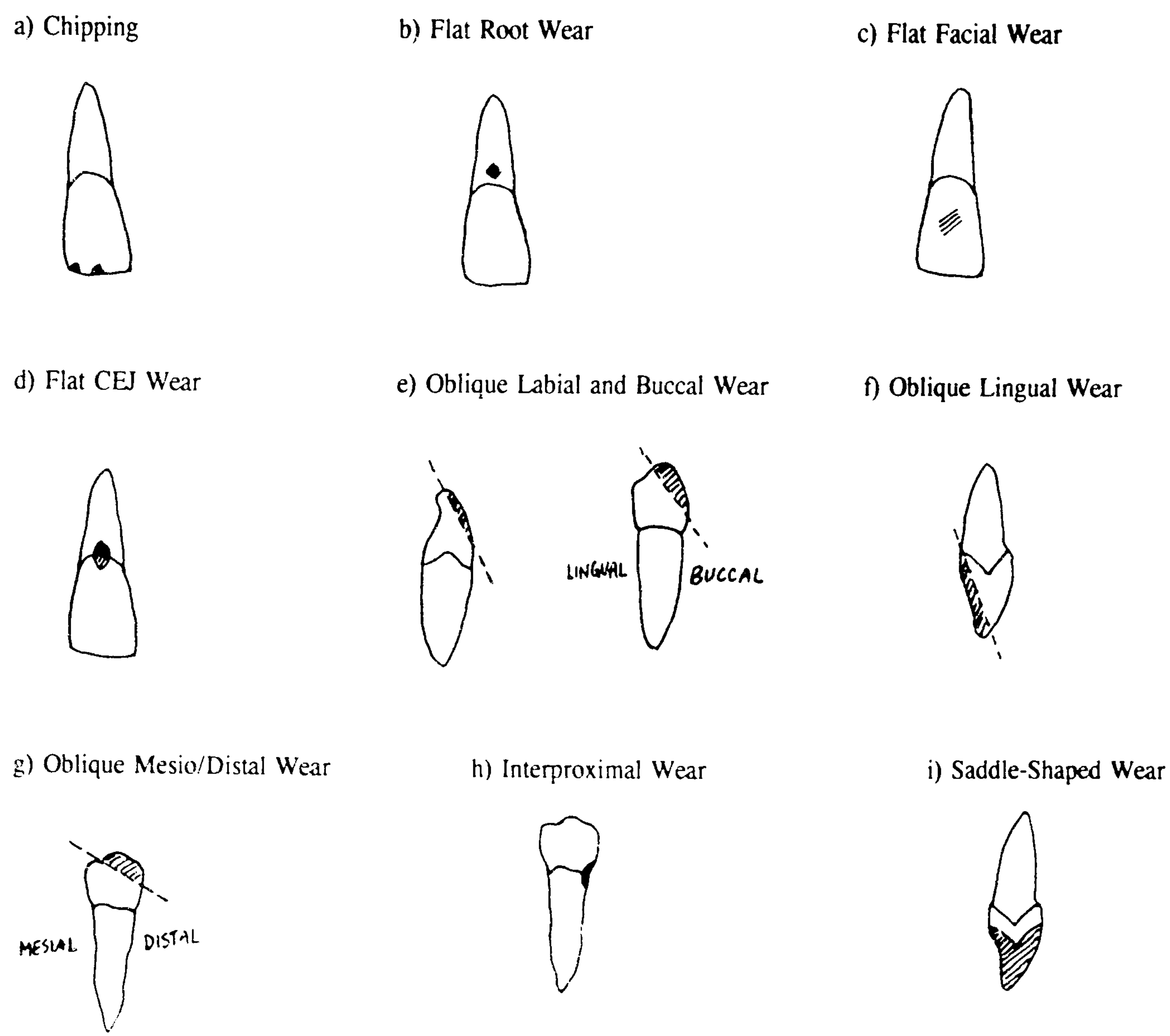
Table 4.3.
Division of Sample by Tooth Class

Time Period

Tooth Class	Old Kingdom	FIP*/Middle Kingdom	Ptolemaic	Total
Incisors	34	23	13	70
Canines	22	14	10	46
Premolars	35	28	13	76
Molars	63	40	22	125
Total	154	105	58	317

*Note: FIP = First Intermediate Period.

Figure 4.1. Illustration of Wear Types



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CHAPTER 5: PATTERNS OF NON-MASTICATORY DENTAL WEAR IN A SKELETAL SAMPLE FROM ANCIENT MENDES, EGYPT

INTRODUCTION

Dental wear studies have long focused on the development of occlusal wear planes and their relationship to the dietary habits of ancient peoples. More recently, researchers have begun to recognize that valuable information can also be obtained through the study of activity-induced dental wear patterns. Activity-induced dental wear patterns appear when the teeth are used for functions other than normal mastication, such as tooth-tool use or habitual activities. Studies of these wear patterns in archaeological samples can aid our understanding of the daily lives of ancient peoples, by revealing some of the effects of their methods of food preparation, craft activities, and habits. This paper presents evidence for activity-induced dental wear in a skeletal sample from Tell el-Rub'a (ancient Mendes), Egypt. Mendes, located in the northeast part of the Nile Delta, is one of the largest and best preserved town sites in the region. Evidence from archaeological and literary sources indicate that this site, which in later times functioned as both a cult centre and administrative capital, was continuously occupied from the Predynastic to the Ptolemaic periods (approximately 4,000 B.C. to approximately 30 B.C.) (Brewer and Wenke 1992; Landy 1979; Redford 1988; Wilson 1982). The various dental wear patterns observed in this sample are interpreted with the aid of statistical analysis, evidence from the Egyptian archaeological record, and ethnographic comparisons with other groups in order to add to our understanding of behavioral activities and daily life in ancient Egypt.

MATERIALS AND METHODS

During the 1976-1978 excavations at Tell el-Rub'a, under the direction of Donald P. Hansen of the Institute of Fine Arts, New York University, a total of 73 burials dating to the Old Kingdom, First Intermediate Period/Middle Kingdom, and Ptolemaic periods, were excavated. Of these burials, the skeletal remains of 53 individuals were shipped to the United States and stored until 1992, when they were brought to the University of Alberta for cataloguing and analysis. The skeletal material was aged and sexed according to standard osteological criteria (Bass 1987; Ubelaker 1989; White 1991) although the fragmentary nature of the remains did not, in most cases, allow for the determination of age categories more specific than "Subadult" (under 18 years) and "Adult" (19 years or older). Nine subadult skeletons were excluded from dental wear analysis because in subadults, the full complement of permanent teeth is not in occlusion long enough for distinctive wear patterns to develop. The sample was further reduced by the exclusion of 18 individuals for which no dentition was recovered. In this way the sample size was reduced to 26 individuals possessing a total of 317 teeth. Because of the small sample size, both the individual count and the tooth count methods were relied upon to provide breakdowns of the sex and time distributions of the sample, which are presented in Tables 5.1 and 5.2. No breakdown of the age distribution is provided, because of the lack of specificity in age categories: all of the individuals used in this study were classified as "Adult". Table 5.3 provides a breakdown of the tooth classes within each time period. One Old Kingdom individual of unknown sex (n=14 teeth) was included in the initial tabulation of wear frequencies, but was excluded from the more detailed breakdowns of wear according to sex in order to better facilitate statistical comparisons, which reduced the total teeth in the Old Kingdom sample from 154 to 140 teeth.

Macroscopic examination of the teeth was conducted with the aid of a ten-power hand lens, and detailed written descriptions were made of any wear that appeared to have been caused by activities other than normal occlusal forces. These written descriptions were then used to form nine separate wear categories, loosely based upon Molnar's (1971) system of scoring wear planes:

1. Chipping: characterized by the removal of small flakes of enamel from the incisal edge or labial surface of the tooth.
2. Flat Root Wear: characterized by polishing or facet formation on the facial surface of the root, directly adjacent to the cemento-enamel junction.
3. Flat Facial Wear: similar to flat root wear, except the polishing was located on the enamel on the facial surface of the tooth.
4. Flat Cemento-Enamel Junction (CEJ) Wear: facet formation on the facial surface of the tooth at the cemento-enamel junction.
5. Oblique Labial/Buccal Wear: oblique or rounded wear that affected the labial or buccal surface of the tooth only.
6. Oblique Lingual Wear: oblique wear that affected the enamel on the lingual surface of the tooth only.
7. Oblique Mesio/Distal Wear: the occlusal or incisal surface of the tooth was worn to a higher level at the mesial edge than at the distal edge; or vice versa.
8. Interproximal Wear: wear facets that appeared between the teeth on or above the cemento-enamel junction and were located closer to the root than contact wear facets.
9. Saddle-shaped Wear: wear extending up onto the enamel of both the labial and lingual surfaces.

Each tooth was scored for the presence or absence of these wear types. Frequency distributions and statistical analysis were conducted using Systat (v. 5.2.1) on the Macintosh. The data was then compared to wear patterns recorded among other population groups and to Egyptian art and archaeological findings in order to determine possible behavioral causes for each of the wear types.

RESULTS AND DISCUSSION

Table 5.4 provides a breakdown of the occurrences of wear types both by tooth count and by individual count, illustrating that most of the wear types occurred in low frequencies throughout the sample, and were often represented by only one or two individuals. For example, although nine occurrences of Flat CEJ wear appear to indicate that it was one of the more widespread wear types in the sample, all nine recorded cases appeared in the dentition of only one individual. For this reason, statistical tests were limited to the three wear types that were observed in a relatively large number of individuals: chipping, oblique labial/buccal wear, and oblique mesio/distal wear. A breakdown of the prevalence of these wear types is given in Table 5.5.

Chi-square analysis (using Fisher's Exact Test and Yates' correction for small sample sizes when necessary) revealed that none of the frequency changes in wear types over time were statistically significant at the 0.05 level, with the exception of oblique mesio/distal wear, which exhibited a significant increase from the Old Kingdom to the FIP/Middle Kingdom (discussed below).

The most commonly observed wear type within the sample was dental chipping (35 cases). As illustrated by Table 5.5, however, chipping was not evenly distributed throughout the sample. Comparisons of the frequencies of the different wear types within each time period revealed that in the Old Kingdom chipping was by far the more prevalent wear type. Although this distinction was not statistically significant, it may nevertheless be of practical significance for interpreting activity patterns. Chipping was, in all but two instances, observed on either the incisors or the canines. Because of the limitation of this wear pattern to the anterior teeth, chipping was re-examined in this context. Table 5.6 illustrates a gradual decrease in the prevalence of chipping of the anterior teeth over the three time periods. Although the decrease was not of sufficient magnitude to register as statistically significant, it is nonetheless an interesting trend in the data that may in fact have proven to be statistically significant, had the sample size been larger.

A further breakdown into male and female groups for each wear type and time period was conducted in order to observe whether different wear appeared more in one sex than the other, or if any trends or patterns within each sex over time could be noticed. Chi-square tests (using Yates' correction and Fisher's Exact Test) between males and females of each time period for the three different wear types did not reveal any statistically significant sex differences at the 0.05 level, with the exception of chipping in the First Intermediate Period/Middle Kingdom, which did prove to have a higher prevalence in males than in females. Additional chi-square sex-controlled comparisons across the three time periods were also attempted, however, these tests were largely unsuccessful due to small sample sizes. Only dental chipping, (which showed no significant changes within males), demonstrated a significant (at the 0.05 level) decline in frequency within females over time.

Interproximal Wear

The etiology of interproximal wear has been the subject of much debate in the anthropological literature. It has been attributed to activities including chemical erosion (Brothwell 1963); forcing grit-laden saliva between the teeth during swallowing (Wallace 1974); pulling a fibrous substance between the teeth (Brown and Molnar 1990; Lukacs and Pastor 1988); and habitual, therapeutic, or palliative probing (Alt and Kockapan 1993; Bermudez de Castro and Perez 1986; Berryman et al. 1979; Frayer 1991; Owsley and Bellande 1982; Ubelaker et al. 1969). Two instances of interproximal wear were recorded in this sample: one was in the form of an oval-shaped facet located on the root of the tooth, directly associated with a large carious lesion at the cemento-enamel junction. Several other researchers who recorded similar wear in various North American Indian groups noted a correlation between interproximal abrasion and dental caries, which appears to support the theory that the wear resulted from probing with a "toothpick" in an attempt to relieve the discomfort of a carious tooth (Berryman et al. 1979; Milner and Larsen 1991; Owsley and Bellande 1982). The second instance of interproximal wear appeared as a shallow channel located near the cemento-enamel junction of an upper right second premolar and was not associated with any dental decay. This wear may have been the result of an occupational activity such as drawing fibrous material between the teeth (Brown and Molnar 1990; Lukacs and Pastor 1988). However, none of the other observable premolar or molar teeth in this individual exhibited the same wear, as would be expected if this were indeed the cause. A second possibility thus may be more likely: that habitual (instead of palliative) use of a toothpick caused the wear to occur.

Flat CEJ and Flat Root Wear

Flat CEJ and flat root wear only appeared within the dentition of one individual in the sample, 5MB12, an adult female, and their similar appearances suggest that they were caused by the same activity. There have been few recorded cases of CEJ wear in studies of other archaeological populations. One historic case of note is that of a sixteenth century ruler of Denmark and Norway, King Christian the Third, who exhibited abrasion at the cemento-enamel junction which was attributed to cleaning the teeth with a fine abrasive material (Pederson 1979). This type of CEJ wear has also been noted in the clinical literature and has often been attributed to excessive toothbrushing (Pindborg 1970; Powers and Koran 1973). In some countries, such as India, people brush their teeth using a finger or twig combined with indigenous toothpowders (Pindborg 1970). Attempts at dental hygiene such as this may have caused the CEJ wear observed in the Egyptian individual, as dental practices were not wholly unknown in ancient Egypt. There is, however, some debate as to exactly how extensive and practical the Egyptians' knowledge was. Information on dental treatments largely comes from written sources such as the Ebers Papyrus and from reliefs and paintings dating mainly to the Old and Middle Kingdoms (David and Tapp 1984; Leek 1967b; Weeks 1980). These treatments were usually pharmaceutical preparations for tooth pain rather than surgical or mechanical intervention (Leek 1967b; Weeks 1980). Although some evidence (such as a purported case of dental surgery and an example of prosthetic dentistry) have been put forth as proof of dental practice in ancient Egypt (Ghalioungui 1973), these examples have been dismissed by many researchers as unconvincing (David and Tapp 1984; Leek 1967a; 1967b; Weeks 1980). Thus, while it is possible that the Egyptians practiced some form of dental care, it may not have extended to hygienic or preventative practices such as toothbrushing. This conclusion is supported by the high frequencies of periodontal disease, calculus and ante-mortem tooth loss found by researchers in many Egyptian skeletal samples, which suggest a lack of preventative dental hygienic practices (Leek 1966; 1967b; Ruffer 1920; Weeks 1980). In addition, the individual in this sample did not show a concentration of the facets on one side of the mouth, which is a commonly observed characteristic of toothbrush-induced abrasion and is an indicator of right or left-handedness in the individual (Barrett 1977).

A second possible cause for the CEJ wear is sinew processing. Sinew processing has usually been regarded by researchers as a cause of interproximal grooving (Brown and Molnar 1990; Lukacs and Pastor 1988), but its role in the formation of CEJ wear has not been fully explored. The processing activity is carried out by inserting sinew between the posterior teeth and pulling it back and forth at the front of the mouth (Figure 5.1). If this is an accurate depiction of the method used for processing sinew or other fibrous material, then it could be the case that the labial surfaces of the teeth were also affected by this repeated action. Ethnographic studies on various North American Indian and Eskimo groups have outlined activities in which the teeth were used for processing fibrous materials, including making cordage from vegetable fibres and softening sinew thread by pulling it across the teeth and rolling it against the cheek (Lous 1970; Schulz 1977). The ancient Egyptians also utilized fibrous plant materials such as flax to fashion thread, rope, and linen (Erman 1971). Although many of their spinning and weaving techniques were advanced enough to utilize instruments such as spindles and looms, some of the initial processing of the plant material may have been carried out in a similar manner as that of the Indian groups. Sinew processing in the manner of the Eskimo could also have been carried out by the ancient Egyptians in order to facilitate their leather-working practices, which flourished along with livestock breeding. Sandal-making techniques, illustrated in tomb paintings, utilized the teeth for threading the sandal straps through the sole (Figure 5.2). It is possible, then, that the straps themselves or the thread used were also processed with the aid of the mouth and teeth.

A possible link between CEJ wear of the molar teeth and interproximal grooving was identified in a skeletal sample from Pakistan, which displayed a close association of the two wear patterns that was attributed to sinew processing techniques (Lukacs and Pastor 1988). The molar teeth of the individual from the Egyptian sample are similarly affected (abraded along the gumline), as are the premolars and the anterior teeth (excluding the central incisors). If this individual (5MB12) exhibited pronounced interproximal grooving in association with the CEJ wear the sinew/fibre processing theory would be strongly supported. Unfortunately, there was only one recorded occurrence of interproximal grooving in the dentition out of 15 observable posterior teeth. The sinew-processing theory cannot be completely discounted, however, because of the appearance of interproximal grooves on the maxillary teeth. Although it likely would have been easier to thread sinew between the mandibular teeth, the maxillary teeth would provide a better anchor for the actual processing action, resulting in less stress on the temporo-mandibular joint. It is therefore possible that some of the interproximal grooving was caused by sinew-processing using the maxillary (and perhaps the mandibular) teeth.

Flat Facial Wear

The flat facial wear observed in the sample appeared as polishing of the facial enamel of the tooth surface. Facial abrasion has been observed in various forms within several archaeological samples and has been attributed to several different activities, three of which appear to best apply to the Egyptian sample: 1) the use of blow pipes in metalworking, 2) holding the mouthpiece of a bow drill, and 3) splitting bamboo or reed (Bermudez de Castro et al. 1988; Lukacs and Pastor 1988). These explanations are not necessarily mutually exclusive, as it is possible that more than one activity was responsible for the formation of this wear.

Techniques for working copper, silver, gold, bronze, and lead were practiced and refined from as early as the Nagada II and III periods (approximately 4,000 - 3,150 B.C.). Most of our knowledge of Egyptian metalworking has been drawn from the analysis of metal artifacts and from tomb art dating to all periods of Egyptian history (Scheel 1989). In order to achieve the high temperatures necessary to melt metal, charcoal-fired hearths were used by the Egyptians to heat the crucible. Metalworkers of the Old and Middle Kingdom fanned the embers using reed blowpipes (Scheel 1989), as shown in Figure 5.3. It is possible that repeated use of these blowpipes could have resulted in their continuous contact and movement against the teeth, which could in turn have caused the smooth labial polishing observed. If this were the case we would expect to observe labial polishing on the teeth which would have come into direct contact with the pipe; namely the incisors. The affected individual in this sample exhibited labial polish not only on the incisor teeth, however, but also on the canines and premolars, which makes this explanation possible although somewhat unlikely.

The use of a bow drill mouthpiece is another plausible explanation for the flat facial wear in the Egyptian sample. Ethnographic evidence from modern Eskimo groups described the use of the front teeth to anchor a bow drill as one of the many craft activities conducted with the aid of the mouth and teeth (Lous 1970; Merbs 1983). Detailed ethnographic accounts of this kind of activity in ancient Egypt do not exist. We do, however, have ample evidence for the use of bow drills from the Egyptian archaeological record, including recovery of the drills themselves, and thousands of examples of beads, woodwork and stonework fashioned through the use of this tool (Montet 1958; Stead 1986). Although tomb paintings show a method of operating a bow drill that does not involve using the mouth, it may be possible that for some craft activities (perhaps those on a small scale, such as bead-drilling) the Egyptians employed a method not unlike that of the Eskimo. If this is the case, we may also accept the suggestion that "slippage of the mouthpiece to the left and right side of the anterior teeth could result in facial abrasion" (Lukacs and Pastor

1988:395). The common occurrence of this tool in the assemblages of the ancient Egyptians combined with the ethnographic knowledge we have from other groups makes this a feasible explanation for some of the labial polishing found in the sample.

The reed splitting theory is also applicable to this sample, because the ancient Egyptians were well known for their exceptional skill at basketry and weaving. Most of their work was done using palm fibre, reeds, grass, and papyrus to produce baskets of various shapes and sizes as well as reed matting used for sandals, beds and floors (Erman 1971; Lewis 1974; Stead 1986). It is likely that the Egyptians, like some modern North American Indian groups, used their teeth to split reeds before using them for weaving baskets and mats. This activity, as described by Larsen (1985), entailed an initial splitting of the reed using the incisal edge, followed by further splitting by sliding the reed along the teeth. In addition to reeds, the Egyptians may also have used their teeth to strip the rind from the papyrus plant, as it grew abundantly in the Delta and was utilized not only for basket and mat weaving, but also for food, rope, and paper (Johnson 1973; Lewis 1974). A connection, however, between this stripping action and the resulting dental wear patterns should first be established ethnographically among modern groups who practice these techniques before this theory is accepted as a decisive explanation for flat facial wear.

Saddle-shaped Wear

Saddle-shaped wear was observed on the maxillary central incisors of only one individual, 5MB12, an adult female from the First Intermediate Period/Middle Kingdom, and affected both the labial and lingual surfaces of the tooth (Plate 5.1). There are no other accounts of saddle-shaped or similar wear in the literature, and thus this wear pattern appears to be rare (possibly even unique) within the archaeological record. A comparable case of saddle-shaped wear has been found in the dentition of a modern skull in the University of Alberta teaching collection, which was obtained from South Asia and has no known provenance (Lovell, pers. comm.). Although a systematic documentation of tooth-tool use in South Asia has yet to be compiled, ethnographic accounts of reed-splitting techniques by North American Indians may instead be useful for explaining this unusual wear. As previously discussed in the above section on flat facial wear, techniques used for splitting reed (or, in the case of the Egyptians, papyrus) can include an initial division of the reed using the incisors as a wedge (Larsen 1985). If this was the practice employed by the Egyptians to split reeds and papyrus for weaving, it is then possible that the material being split simultaneously contacted both the labial and the lingual surfaces of the teeth, which, in turn, may have produced a "saddled" wear pattern.

Oblique Lingual and Labial Wear of Incisors

Four cases of oblique lingual wear were observed within the sample: each was characterized by the complete removal of enamel from the lingual aspect of the upper incisor teeth with associated rounded labial wear on the lower incisors. This pattern is similar to wear recorded among individuals from an archaeological sample in Pakistan, which may have been caused by the pulling of a material such as animal skin between the upper and lower teeth (Lukacs and Pastor 1988). While the direction and nature of the wear allows us to determine with some confidence the action used to produce it (a downwards pulling motion), we must speculate as to what types of material were handled in this manner. The possibility of animal skin processing is supported in part by ethnographic accounts of modern Inuit activities describing how the teeth were used for removing fat and tissue from animal hides, as well as for grasping the skin in order to stretch or shape it (Lous 1970; Merbs 1983). Although Egyptian art and writings have not left exact documentation of the processes by which the Egyptians dressed their skins (Erman 1971), this dental wear pattern provides evidence to show that the Egyptians, who often worked with leather, may have used their teeth in a similar manner as the Eskimo for part of their skin processing techniques.

One manifestation of anterior labial wear observed was unusual enough in itself to warrant special notice: the maxillary right canine of 4MB8, an adult Old Kingdom female, was worn on the facial surface, exposing a triangular-shaped patch of dentin on the distal aspect (Plate 5.2). Unfortunately, none of the corresponding lower teeth were preserved, nor was the maxillary right first premolar, which meant that associated wear on these teeth could not be examined. Interpretation of this wear pattern thus proved to be difficult, due first to the absence of the other teeth and secondly to the fact that this specific manifestation of labial wear has not been addressed in the literature. The activity that produced this wear probably involved pulling a fibrous material (such as string or sinew) which was held at the side of the mouth in an upwards and outwards direction, although without additional evidence further speculation about specific activities would be unfounded.

Oblique Buccal Wear

Oblique wear on the posterior teeth was characterized by the obliteration of the enamel and subsequent rounding of the buccal edge. A posterior wear pattern similar to that seen in the Egyptian sample was also observed among Maori and Moriori skulls, and was attributed to the tipping and dislocation of the posterior teeth caused by repeated chewing of a reserve mass of food kept pressed in the cheek (Taylor 1963). One substance that could have been used in this way by the ancient Egyptians was papyrus, which was a valuable food source because it was both abundant and nourishing. Although papyrus was boiled and roasted for eating, it was also used much as sugar cane is used in other areas of the world: the lower stem of the plant was chewed raw to ingest the juice, and then the quid was discarded (Dixon 1969; Johnson 1973; Kennedy et al. 1986; Lewis 1974; Puech et al. 1983). The fact that Mendes was located in the Delta, an area particularly rich in papyrus resources, makes this explanation extremely plausible, as the people would undoubtedly have relied in part upon the plant for use in this way.

Oblique Mesio/Distal Wear

Two main types of obliquely angled wear were identified in the sample: wear that angled higher at the mesial edge than at the distal edge (mainly found on the posterior teeth); and wear that angled higher at the distal edge than at the mesial edge. The former was the type that occurred the most frequently, was often only expressed to only a slight degree, and was probably not actually a form of unusual wear due to non-masticatory activities. It is most likely that the teeth angled in this manner were worn simply through the development of natural wear planes. The development of these wear planes may have been influenced by various factors, including age and antemortem tooth loss, which both can alter the way in which the teeth meet in occlusion. Another possibility is that the mesio/distal wear is associated with the curved "helicoidal" plane that, in agricultural people such as the ancient Egyptians, developed as a result of the abrasiveness of their diet (Hall 1976; Ruffer 1920; Smith 1984). The link between this curved wear plane and an agriculture-based subsistence mode must be considered when attempting to interpret the statistically significant increase of oblique mesio/distal wear between the Old Kingdom and First Intermediate Period/Middle Kingdom. This increase can not be correlated to any major shift in the Egyptian economy to a greater reliance on agriculture, as this shift occurred much earlier, during the Predynastic period (Hassan 1988). In addition, there are no mentions in the literature of a dramatic shift in food resources or the adoption of new, habitual activities that may account for the wear increase. It is therefore likely that the increase is an anomalous occurrence and is not related to any meaningful trends or patterns.

Not all of the obliquely angled wear can be so easily explained, however, since there are a few instances where the wear of the tooth angled in the opposite direction to what would be expected from normal occlusal planes. One such example was found in 4MB5, an adult female from the First Intermediate Period/Middle Kingdom, who exhibited a distinctive wear between two premolars: one was angled downwards and the other angled upwards, forming a curved, scoop-like line along the occlusal plane. This type of wear probably resulted from the repeated holding of a foreign substance between the teeth which resulted in the gradual abrasion of the tooth surface to accommodate this substance. Although abrasion patterns similar to this have been linked to the clenching of a pipe stem between the teeth (Barrett 1977; Pindborg 1970), pipe smoking does not appear to be a likely explanation in this case, since, in contrast to the sharply defined wear margins associated with pipe stem abrasion, the premolars of 4MB5 exhibited margins that were smooth and rounded. This supports the alternate possibility that the wear was caused by the holding of a quid in the cheek, a practice which could result in the cupping of the dentine on the teeth where the quid was chewed. Ethnographic accounts of quid chewing among Aborigine and Yuendumu groups have linked the practice to this wear pattern (Barrett 1977). The rounded enamel rim was the result of the quid pressing out against the cheek, where it would be frequently squeezed against the buccal surfaces of the teeth to extract the juices. As previously mentioned, the use of masticatories was widespread in Ancient Egypt, and was practiced by individuals from both sexes and all social classes (Dixon 1969; Kennedy et al. 1986). In addition to papyrus, the Egyptians chewed quids made of roasted watermelon seeds, natron, gum resins, myrrh, pignon, rush-nut, honey, calamus aromaticus, cinnamon, frankincense and ladanum to extract the juices, to freshen their breath, and to treat mouth ailments (Dixon 1969; Ghalioungui 1973; Kennedy et al. 1986). Specific mention of the practice among women is made in the Ebers Papyrus, which describes how females mixed resins and honey to form small pellets which they chewed to sweeten their breath (Dixon 1969). This evidence, combined with our knowledge of the effects of quid chewing on the dentition in other population groups, makes the use of masticatories an extremely likely explanation for this form of oblique wear.

One case of oblique mesio/distal wear proved to be the most unusual of any of the numerous variations in wear patterns. This wear was found on the right central incisor of 5MB36, an adult Ptolemaic male, and can only be described as the complete obliteration of the distal portion of the tooth on a diagonal so that the mesial corner of the incisal edge is present, but the distal corner has been worn away (Plate 5.3). There are three possible causes for this wear: the first is an occupational or non-masticatory activity that involved a repeated or continuous abrasion diagonally along the central incisor. Unfortunately, none of the tooth-tool use activities which have been described in the literature seem to involve a motion likely to result in wear of this nature. A second possibility is that the tooth was fractured prior to death, and that over time the edge smoothed out through normal wear. However, this explanation is unlikely mainly because if the tooth had been broken, it would likely be much more irregular and asymmetrical in appearance. The third possibility is that the modification was intentional and was performed for a ritual or decorative purpose. Intentional dental modification is practiced among people from all areas of the world including Africa, North and South America, India, and the Caribbean (Goose 1963; Handler et al. 1982; Kennedy et al. 1981; Romero 1970; Walker and Hewlett 1989; Willey and Ubelaker 1976). The incisal wear of 5MB36 is so unique that no ethnographic information on tooth-tool use in other groups adequately accounts for it. This could, by process of elimination, be used to support the intentional modification theory. Unfortunately, there have not been any previously recorded cases of intentional dental modification in the teeth from Egyptian skeletal samples, which does not negate the possibility, but makes it somewhat less likely to be true. Microscopic examination of the worn surface could be helpful for determining if a natural substance caused the wear, or if it was the result of filing.

Chipping

Dental chipping of the anterior teeth was the most widely observed wear pattern within the Egyptian sample, and appeared to gradually decrease in frequency over time. Ethnographic accounts of tooth-tool use among modern Eskimo groups have linked dental chipping to the chewing of bones (Turner and Cadien 1969), which may have also been a factor in the etiology of the chipping in the Egyptian sample.

Although the Egyptians did not rely as heavily upon meat as did the Eskimo, they did incorporate game, fowl and fish into their varied diet (Montet 1958). The decrease in chipping observed among females over time may be associated with changes in food preparation or craft techniques over time, for although the details of the daily running of Egyptian households remain obscure (Baines and Malek 1980), it is likely that as Egypt expanded its contacts with the outside world (particularly during the Ptolemaic period), traditional techniques may have been replaced by modified ones that relied more on actual tools and utensils, and less on the "third hand" provided by the teeth. Some of the chipping in the sample may also be the result of retouching stone tools by biting the flake, an activity which has been recorded among Australian Aborigines and may result in damage to the enamel of the anterior teeth in the form of chipping (Barrett 1960; Gould 1968; Lukacs and Pastor 1988). The practice of flint-working was widespread in ancient Egypt, as evidenced by flint knives, sickle blades, and lances which date from prehistoric to Roman times. While the technique of retouching these tools using the teeth may not account for all of the cases of chipping observed in the sample, it certainly may have been a factor in producing some of this wear. Changes in tool technology may also be the reason that the prevalence of chipping decreased from the Old Kingdom to the Ptolemaic periods. Reliance on flint blades for agricultural implements appears to have declined, particularly during the Ptolemaic period when the establishment of mass-production foundries and the import of new metal tools and tool-making techniques into Egypt made metal implements much more common (Scheel 1989). This explanation would also account for the higher frequencies of chipping among males than among females within the first two time periods (a discrepancy which was statistically significant in the First Intermediate Period/Middle Kingdom), as the stone tool industry was likely operated by men. Recreational activities are a third possible cause for the dental chipping in the sample. Clinically, it has been recognized that the most frequent causes of dental chipping are games, sports, and fights (S. Compton, pers. comm.). The Egyptians were extremely fond of games, and accounts of their recreational pastimes include several games that incorporated physical contact and vigorous activity, such as wrestling and obstacle races (Montet 1958). It is therefore possible that activities such as these were responsible in part for some of the occurrences of dental chipping observed in the sample.

CONCLUSION

The examination of activity-induced patterns of dental wear in the skeletal sample from Mendes has shown that traditional methods of anthropological investigations into the dental wear, diet, and activities of ancient peoples can be supplemented through both ethnographic comparisons and archaeological resources such as ancient writings, art, and artifacts. Information derived from each of these sources has enabled us to draw several conclusions about unusual wear patterns in ancient Egypt, including:

1) The three most frequently observed wear patterns in the sample were chipping,

oblique labial/buccal wear, and oblique mesio/distal wear.
2) Chipping, which was the most common wear pattern in the sample, exhibited a gradual decrease in prevalence over the three time periods. This type of wear may be due in part to the chewing of bones as part of the diet, and to recreational activities such as games or sports. New food preparation and craft techniques resulting from increased culture contact and trade may be the cause of the decreased frequency in chipping among females over the three time periods. Some of the occurrences of chipping may have resulted from the use of the teeth to finish flint blade edges, a hypothesis which is supported by the higher frequencies of chipping in men than in women during the Old Kingdom and First Intermediate Period/Middle Kingdom. The decreased frequency of chipping over time may be the result of a decline in this method of tool preparation, and an increased reliance upon metal tools in later periods.
3) The oblique lingual wear and associated oblique labial wear of the upper and lower incisors provide evidence that the Egyptians used their teeth to process animal hides as part of their leather-working practices.
4) Oblique buccal wear and the scoop-like pattern of oblique mesio/distal wear were likely the result of chewing quids made of substances including papyrus, gum resins, natron, or watermelon seeds for habitual, nutritive, or therapeutic purposes.
5) Comparative ethnographic evidence indicates that activities such as toothpick use, fibre or sinew processing, metal working, bow drill manipulation, weaving, and perhaps even intentional dental mutilation were all possible etiological factors for other patterns of dental abrasion recorded.

Additional research on activity-induced dental wear patterns will benefit from microscopic examination of the abraded surfaces of the teeth, as this will enable researchers to better determine both directionality and etiology of the abrasions. Another valuable endeavour for future research would be a systematic examination of the existing collections of Egyptian skeletal material, in order to document additional occurrences of these and other unusual forms of dental abrasion. Finally, detailed ethnographic documentation of non-masticatory tooth use among modern populations with varied diets, subsistence technologies, and craft activities would greatly facilitate comparisons between ancient and modern patterns of behavior.

Table 5.1.
Sex Composition of the Skeletal Sample
(Individual Count)

Time Period

Sex	Old Kingdom	FIP*/Middle Kingdom	Ptolemaic	Total
Females	6	3	3	12
Males	6	6	1	13
Unknown	1	0	0	1
Total	13	9	4	26

*Note: FIP = First Intermediate Period.

Table 5.2.
Sex Composition of the Skeletal Sample
(Tooth Count)

	Time Period			
Sex	Old Kingdom	FIP*/Middle Kingdom	Ptolemaic	Total
Females	65	60	54	179
Males	75	45	4	124
Unknown	14	0	0	14
Total	154	105	58	317

*Note: FIP = First Intermediate Period.

Table 5.3.
Division of the Sample
by Tooth Class

Time Period

Tooth Class	Old Kingdom	FIP*/Middle Kingdom	Ptolemaic	Total
Incisors	34	23	13	70
Canines	22	14	10	46
Premolars	35	28	13	76
Molars	63	40	22	125
Total	154	105	58	317

*Note: FIP = First Intermediate Period.

Table 5.4. Frequencies of Wear Types Observed

Wear Type	Frequency: Individual Count (n=26) #	Individual Count (n=26) %	Tooth Count (n=317) #	Tooth Count (n=317) %
Chipping	15	58	35	11
Flat Root	1	4	1	0.3
Flat Facial	1	4	6	2
Flat CEJ*	1	4	9	3
Oblique Labial/Buccal	6	23	10	3
Oblique Lingual	3	12	4	1
Oblique Mesio/Distal	8	31	19	6
Interproximal	2	8	2	0.6
Saddle-shaped	1	4	2	0.6

*Note: n = total teeth in sample; # = number affected; % = #/n * 100; CEJ = cemento-enamel junction.

Table 5.5. Frequency Distribution of Most Common Wear Types
by Time Period
(Tooth Count Method)

Frequency

Wear Type	Old Kingdom (n=154)		FIP/M.K. (n=105)		Ptolemaic (n=58)	
	#	%	#	%	#	%
Chipping	21	14	10	9.5	4	7
O. Lab./Bucc.	5	3	5	13	0	0
O. Mesio/Dist.	2	1	13	12	4	7

*Note: FIP/MK = First Intermediate Period/Middle Kingdom;
O. Lab./Bucc. = Oblique Labial/Buccal; O. Mesio/Dist. = Oblique Mesio/Distal;
= number observed; % = number observed divided by total teeth in time period.

Table 5.6.
Chipping Frequencies of the Anterior Teeth
by Time Period

	Frequency	
Time Period	#/n	%
Old Kingdom	19/56	34
FIP/Middle Kingdom	10/37	27
Ptolemaic	4/23	17

*Note: n = total teeth present in category; # = number of affected teeth; % = #/n*100

Table 5.7. Male and Female Wear Frequencies Over Time

TIME PERIOD	SEX			
	Male		Female	
	#/n	%	#/n	%
OLD KINGDOM				
Chipping	10/75	13	11/65	17
O. Labial/Buccal	3/75	4	2/65	3
O. Mesio/Distal	1/75	1	1/65	2
FIP/MIDDLE K.				
Chipping	8/45	18	2/60	3
O. Labial/Buccal	3/45	7	2/60	3
O. Mesio/Distal	5/45	11	8/60	13
PTOLEMAIC				
Chipping	0/4	0	4/54	7
O. Labial/Buccal	0/4	0	0/54	0
O. Mesio/Distal	4/4	100	0/54	0

*Note: n= total teeth present in category; # = number of affected teeth; % = #/n * 100;
O. Labial/Buccal = Oblique Labial/Buccal; O. Mesio/Distal = Oblique Mesio/Distal

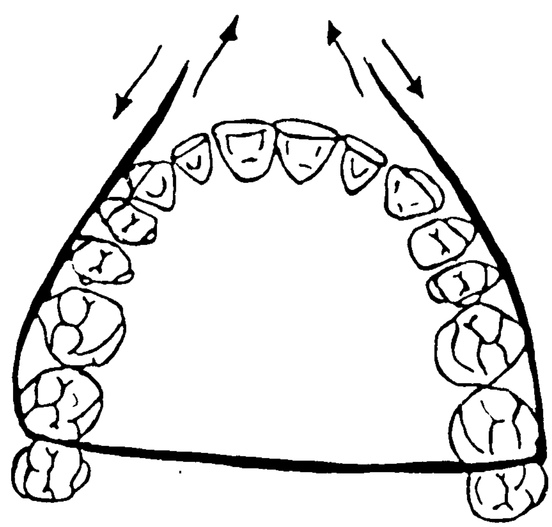

Figure 5.1.
Occlusal view of the dentition, showing
possible mode of cemento-enamel junction wear formation
by fibre or sinew processing.
(adapted from Lukacs and Pastor 1988:388)

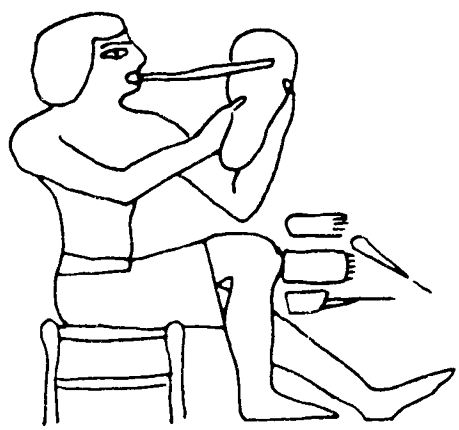

Figure 5.2.
Tomb relief, depicting sandal-making techniques.
(adapted from Montet 1958:154)

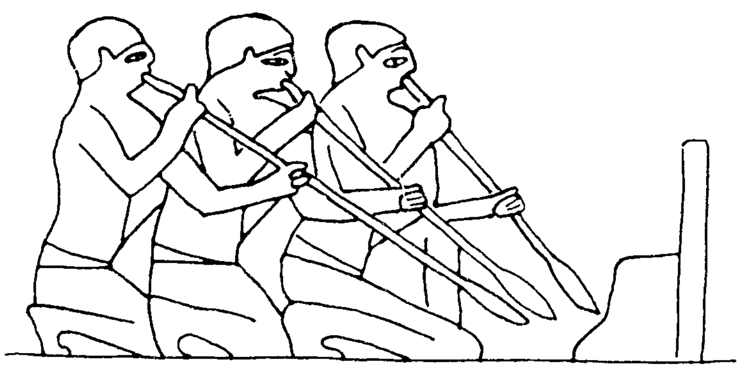

Figure 5.3.
Tomb relief, depicting the use of blow pipes
in metalworking.
(adapted from Scheel 1989:23)

Plate 5.1.
Saddle-shaped wear of the maxillary central incisors
(lingual surface).

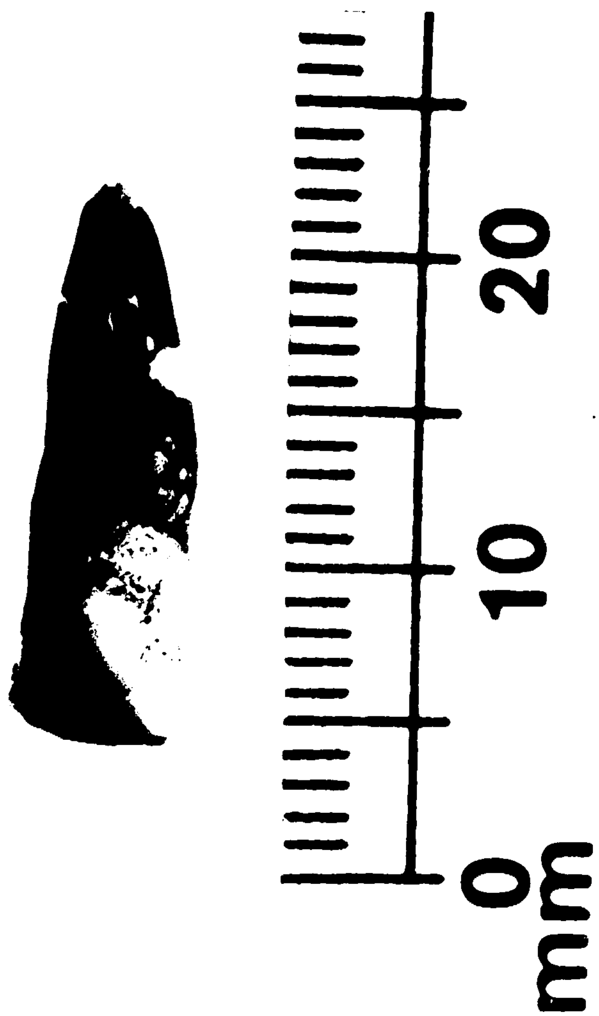

Plate 5.2.
Oblique labial wear of the maxillary right canine.

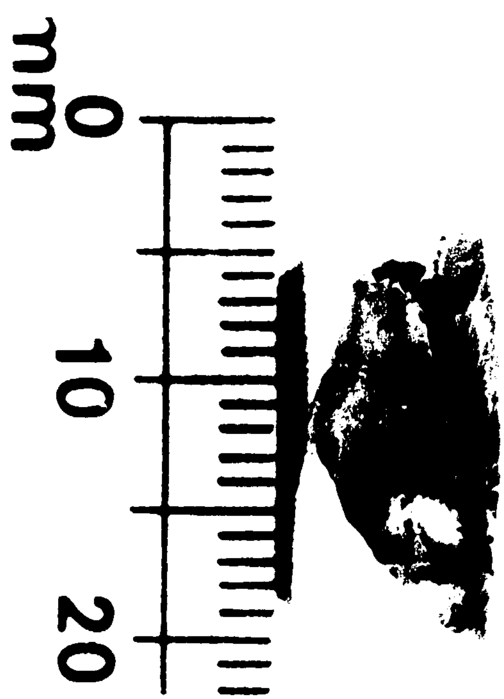

Plate 5.3.
Oblique mesio/distal wear of a maxillary central incisor.

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CHAPTER 6: ACTIVITY-INDUCED DENTAL ABRASION IN A SKELETON FROM ANCIENT MENDES, EGYPT

INTRODUCTION

Dental wear studies have provided researchers with much information regarding the diet, food preparation methods, masticatory movements, and occupational activities of ancient peoples. Although much of the work that has been done in this area has focused on patterns of occlusal tooth wear (e.g. Anderson 1965; Patterson 1984, 1986; Smith 1972), there is also a growing body of research dedicated to the interpretation and analysis of activity-induced dental abrasion patterns (e.g. Larsen 1985; Lukacs and Pastor 1988; Molnar 1971, 1972; Schulz 1977). These studies can be of great value for increasing our understanding of the daily lives of ancient peoples, as they provide a record of occupational, habitual, or compulsive behaviors. As these studies have progressed, a variety of analytical tools have been relied upon in order to better facilitate interpretation, including ethnographic comparisons with other groups, archaeological sources, ancient art and literature, and approximal scanning electron microscopy (SEM). Each of these methods is employed in this study on the activity-induced wear patterns on the dentition of an adult female skeleton from the Nile Delta site of Mendes, an administrative capital and cult centre which was occupied from the Predynastic to the Ptolemaic periods. The aim of this study is to document unique patterns of abrasion, and to determine possible etiological factors for these patterns in order to increase our understanding of daily life in ancient Egypt.

MATERIALS AND METHODS

The material used in this study was drawn from a skeletal sample excavated during the 1976-1978 field seasons at Tell el-Rub'a (ancient Mendes) under the direction of Donald P. Hansen at Institute of Fine Arts, New York University. The sample, which was brought to the University of Alberta in 1992 for cataloguing and analysis, was aged and sexed according to standard osteological criteria (Bass 1987; Ubelaker 1989; White 1991), and the dentitions from the adult specimens were examined for signs of unusual wear. Teeth from each individual were examined macroscopically with the aid of a ten-power hand lens, and detailed written descriptions were made of any wear that appeared to have been caused by activities other than normal occlusal forces. The data was then divided into categories of wear, loosely based upon Molnar's (1971) system of scoring wear planes:

1. Chipping: characterized by the removal of small flakes of enamel from the incisal edge or labial surface of the tooth.
2. Flat Root Wear: characterized by polishing or facet formation on the facial surface of the root, directly adjacent to the cemento-enamel junction.
3. Flat Facial Wear: similar to flat root wear, except the polishing was located on the enamel on the facial surface of the tooth.

4. Flat Cemento-Enamel Junction (CEJ) Wear: facet formation on the facial surface of the tooth at the cemento-enamel junction.
5. Oblique Labial/Buccal Wear: oblique or rounded wear that affected the labial or buccal surface of the tooth only.
6. Oblique Lingual Wear: oblique wear that affected the enamel on the lingual surface of the tooth only.
7. Oblique Mesio/Distal Wear: the occlusal or incisal surface of the tooth was worn to a higher level at the mesial edge than at the distal edge; or vice versa.
8. Interproximal Wear: wear facets that appeared between the teeth on or above the cemento-enamel junction, located closer to the root of the tooth than contact wear facets.
9. Saddle-shaped Wear: wear extending up onto the enamel of both the labial and lingual surfaces.

The dentition of 5MB12, an adult female (28-54 years) from the First Intermediate Period/Middle Kingdom, was selected for detailed study for two reasons, the first being that examples of all but one of the observed wear patterns in the sample were expressed in the dentition, and secondly because all occurrences of flat wear (including facial, root, and CEJ wear) and saddle-shaped wear were limited to this individual (see Table 6.1). Three teeth from this individual were selected for analysis using the scanning electron microscope: the maxillary left lateral incisor (LI2)[1], representing flat CEJ wear; a maxillary central incisor (I1) (which could not be sided due to extensive wear and some postmortem breakage) representing saddle-shaped wear, and the first left mandibular molar (LM1), representing both oblique buccal wear and flat CEJ wear.

The teeth were coated with a layer of carbon using a Hitachi HUS-4 vacuum evaporator. Microscopic examination was then carried out using a Hitachi Model S-2700 Scanning Electron Microscope, in the Department of Mining, Metallurgical, and Petroleum Engineering at the University of Alberta. The gross size, shape, and orientation of the abraded areas were recorded, employing magnifications ranging from 25 x to 570 x. The distinction between antemortem and postmortem microwear was recognized based upon the criteria outlined by Teaford (1988b), including pattern, regularity, and distribution of wear. Any wear features that appeared to be isolated, extreme, or highly irregular as compared to the wear on the rest of the tooth were regarded as caused either by postmortem wear, cleaning, or sample preparation and were not included in the analysis. Interpretations of the wear patterns were then attempted based upon the macroscopic and microscopic examinations, ethnographic comparisons with other groups (both ancient and modern), and on Egyptological sources of art and literature.

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[1] This is the nomenclature that is commonly used for identifying teeth in Physical Anthropology: R and L = right and left; I1 and I2 = central and lateral incisors; C = canine; PM1 and PM2 = first and second premolars; M1, M2, and M3 = first, second and third molars.

RESULTS AND DISCUSSION

Left Maxillary Lateral Incisor

The CEJ wear exhibited by the maxillary LI2 appeared as a triangular-shaped facet which covered a portion of both the root and the enamel, exposing the underlying dentine (Plates 6.1 and 6.2). Visual examination revealed slight mesio/distal scratches within the shallowest portions of the facet (the upper and lower borders). This specimen also exhibited facial polishing of the enamel surface, as well as some lingual wear. Associated teeth included the left central maxillary incisor, which did not show similar wear, and the maxillary LPM1, which did exhibit a wear facet at the cemento-enamel junction. The left maxillary canine was not recovered.

A low-power micrograph of the labial enamel directly adjacent to the wear facet (Plate 6.3) illustrates several parallel striations on the surface area of varying size and depth, with several large, deep scratches surrounded by numerous fine striations. In this low-resolution view, the predominant direction of the scratches appears to be horizontal. This horizontal wear continues onto the area of the facet itself, as illustrated by Plate 6.4, which is a higher-resolution micrograph of the facet and part of the adjacent enamel. The striations on the facet exhibit the same directionality that was observed on the enamel, although the concentration of these features appears to be denser near the cervical portion of the facet than at the apical portion. These visual observations were further supported by quantitative methods of analysis, which indicated that the vast majority of the microwear striations present on the areas observed were oriented horizontally (Heidler, unpublished manuscript).

Determining the etiology of the CEJ wear facets has proved to be quite complex. Although it is clear from the SEM analysis that the abrasion was the result of a horizontal or side-to-side motion, it is less clear exactly what the activity may have been. Observations of similar wear patterns among other groups have led researchers to suggest fibre or sinew processing, or excessive toothbrushing as possible causes of this type of facial abrasion (Lukacs and Pastor 1988; Pederson 1979). The sinew-processing hypothesis, which was derived in part from observations of dental abrasion in a skeletal sample from Pakistan, states that a fibrous material such as sinew or vegetable cordage could be threaded between the posterior teeth and then pulled back and forth at the front of the mouth (Figure 6.1). The resulting interproximal grooving may be accompanied by buccal abrasion near the cemento-enamel junction, on the associated teeth. Unfortunately, the evidence from 5MB12 does not support this, as the individual only exhibited one instance of interproximal grooving out of 15 observable posterior teeth. The toothbrushing theory appears more likely, simply because of the similarity between the back and forth action often used for this activity and the horizontal nature of the striations. Clinical and archaeological evidence for this type of abrasion, however, reveal that the wear resulting from excessive toothbrushing usually appears in the form of wedge-shaped notches as opposed to flat, polished wear facets (Pindborg 1970; Powers and Koran 1973). It may be possible that the abrasion was caused not by an actual toothbrush, which is composed of synthetic bristles laid out in a regular pattern, but through the use of a twig that was prepared so that it was softened and frayed, a practice still common to this day in some regions of India and elsewhere (Pindborg 1970). If this was the case, it could account for the contrast between the wedge-shaped lesions sometimes caused by modern toothbrushing practices, and the less severe flat, polished wear facets observed on the Egyptian teeth. Although this theory appears to be the more likely of the two given the evidence at hand, it cannot be unequivocally accepted, due both to the difference between these wear facets and those described in the clinical literature, and to the lack of consensus by scholars as to whether dentistry was practiced in ancient Egypt. Although archaeological evidence such as a possible prosthetic device, a reputed case of dental surgery, and literary references from the Ebers Papyrus have all been cited as proof of a specialized dental profession in ancient Egypt (Ghalioungui 1973), many researchers have discounted this evidence as unconvincing (David and Tapp 1984; Leek 1967a, 1967b; Weeks 1980). In addition, high frequencies of calculus and antemortem tooth loss have been observed within the dentitions of many of the ancient Egyptian skeletal samples, which would tend to suggest that dental hygiene was not a common practice (Leek 1966, 1967b; Ruffer 1920; Weeks 1980). Therefore, although the SEM analysis has provided us with evidence for the directionality of the wear, its exact etiology is still to some degree a matter of speculation.

Maxillary Central Incisor

The saddle-shaped wear observed on the maxillary central incisor is described as the obliteration of the enamel on both the labial and lingual surfaces of the tooth, exposing much primary dentine. Viewed approximally, this wear angled obliquely outwards from a point on the remaining incisal edge (Plate 6.5). The wear appears to extend closer to the cemento-enamel junction of the lingual surface than the labial. Very little of the enamel remains on the tooth, except for a few millimetres near the root on all sides. The other central incisor exhibited the same unusual wear pattern, although the adjacent maxillary LI2 did not. The only other closely associated tooth that was recovered was the mandibular RI2, which showed flat wear in the form of labial polishing and a CEJ facet.

A low-power micrograph (Plate 6.6) of the labial surface illustrates the expanse of dentine that has been exposed. The sharply defined fracture on the right side of the picture is due to postmortem breakage. Note the variation of microwear features apparent on the dentine, including some prominent rough deep scratches that run obliquely and vertically. Several finer horizontal striations are also apparent.

The enamel surface directly adjacent to the exposed dentinal area (located near the centre of the tooth) again shows scratches of a horizontal orientation, similar to those observed on the facial surface of the corresponding LI2 (Plate 6.7). Although some of the scratches are quite marked in appearance, the majority of the striations are very small and fine. There is some continuity between the scratches on the enamel and those on the dentine, as is illustrated by Plate 6.8. The transition between the enamel on the right and the dentine on the left is clearly demarcated, and the continuation of the horizontal striations across both regions is also obvious, although the dentine does not reflect the same number of striations apparent on the enamel.

Closer examination of the dentine does not, in fact, reveal the same overwhelmingly horizontal predominance of striations observed on the enamel. Instead, there is some variability in the microwear of this region, as illustrated by Plate 6.9. This micrograph, which illustrates the roughness and porosity of the dentine, also reveals a number of striations that appear to run not only horizontally, but obliquely as well. These observations of labial microwear are supported by quantitative analysis, which indicated that the enamel microwear is predominantly horizontal in orientation, as is the dentine, although the dentine also exhibits a high degree of oblique wear (Heidler, unpublished manuscript).

The lingual surface of the tooth was found to exhibit patterns of microwear that were quite distinct from those observed on the labial surface. The horizontal wear that was so easily observed labially does not appear as a predominant feature of the lingual surface at all. Instead, the lingual surface enamel (Plate 6.10) reveals several scratches and striations that appear to be vertical or slightly oblique in orientation. In addition, several pits in the enamel were noted, a characteristic which was not observed to nearly the same extent on the labial surface.

The dentine on the lingual surface does not show as clear an image of overall feature directionality. Plate 6.11 is a representation of the lingual dentine, which, much like the labial dentine, is extremely rough and porous in texture. There are considerably fewer scratches than on the labial dentine, and those that are present do not indicate a clear directional orientation. Near the incisal edge, however, we are again able to observe well-defined microwear features that show clear directionality: Plate 6.12 shows the lingual surface and the incisal edge characterized by a dense layout of pits and scratches, many of which appear to run linguo-labially over the incisal edge towards the front of the tooth.

The evidence presented above for saddle-shaped wear in the dentition of 5MB12 is particularly interesting because it is not only unique within the Mendes sample, but is apparently unique within the archaeological record. This uniqueness, unfortunately, presents a complication for any attempts to determine the etiology of this wear, as there have been no other accounts of saddle-shaped or similar wear in the literature. The only comparable case of saddle-shaped wear has been found in the dentition of a modern skull in the University of Alberta teaching collection, which was obtained from South Asia and has no known provenance (Lovell, pers. comm . It is possible that ethnographic accounts of tooth-tool use in South Asia could be of value for interpreting the saddle-shaped wear, however, until such an account is compiled, we are limited to the evidence obtained from the SEM analysis for our interpretations.

It is interesting to note that the microwear on the lingual enamel and dentine, which appeared to be predominantly vertical and oblique, was quite different from that observed on the labial enamel and dentine, which was predominantly horizontal. This is suggestive of two separate activities being performed using the central incisors: one involving mainly the lingual surface, one limited to the labial.

The directionality of the wear on the lingual surface appears to be consistent with an action involving the continuous pulling of an abrasive substance such as animal skin between the upper and lower teeth. The activity may have incorporated a motion that drew the material both outwards and slightly upwards. This motion would have resulted in contact between the material and both the lingual and the labial surfaces of the teeth, which could have contributed to the exposure of the dentine in the characteristic saddle-shaped pattern. If this is the case, it would account for why the labial surface was not affected to the same extent as the lingual, for the material would not have come into contact with the labial surface to the same extent. It would also account for the continuous scratches observed along the linguo-incisal edge of the tooth. Ethnographic accounts of modern Inuit activities have described how the teeth were used for removing fat and tissue from animal hides, as well as for grasping the skin in order to stretch or shape it (Merbs 1983; Lous 1970). Although Egyptian art and writings have not provided exact accounts of how the Egyptians dressed their skins (Erman 1971), there is evidence to show that they did use their teeth for some leather-working practices such as sandal making (Figure 6.2). This knowledge, combined with the dental wear pattern observed, indicates that the Egyptians may also have used their teeth in a similar manner as the Eskimo for part of their skin processing. Dental abrasion associated with this activity has not typically extended upwards onto the labial surface (Lukacs and Pastor 1988), however, if the motion involved included an upwards direction as hypothesized above, it is possible that hide processing was responsible for a portion of the labial wear observed.

Another practice which could have caused the saddle-shaped wear pattern is the splitting of vegetable material such as reeds or papyrus to use for weaving baskets, mats, and rope, as practiced by some modern North American Indian groups (Larsen 1985). This activity involves an initial splitting of the reed using the incisors as a wedge, followed by further splitting by sliding the reed along the teeth (Larsen 1985). The ancient Egyptians, who were well known for their exceptional skill at basketry, practiced their weaving techniques using reeds, papyrus, palm fibre, and grass (Erman 1971; Lewis 1974; Stead 1986). If the reed splitting practice described among North American Indians was also employed by the Egyptians as part of their weaving techniques, it is then possible that the reeds or papyrus being split gradually wore away both the labial and lingual surfaces of the teeth, which, in turn, may have produced this distinctive "saddled" wear.

The labial surface, in contrast to the lingual surface, was characterized by predominantly horizontal microwear features. These features, which appear to be unrelated to the vertical lingual wear, may have been superimposed upon the original labial wear. Field and laboratory studies of microwear among primates have demonstrated that microwear features can change quite rapidly: in some cases new features can be created in a single day (Teaford 1991; Teaford and Glander 1991; Teaford and Oyen 1986; Walker et al. 1978). It appears likely that hide processing or reed splitting using the incisal edge caused the original saddle-shaped wear, upon which further horizontal microwear was superimposed by additional nonmasticatory activities, such as /sinew processing, toothbrushing, or the splitting of reeds or papyrus by sliding them along the teeth (Larsen 1985). Although direct associations between this practice and labial dental abrasion have not been ethnographically established, it is likely that the Egyptians, (particularly the women), who were extremely skilled weavers, utilized this kind of preliminary processing technique for their raw materials.

Examples of pitting, multidirectional scratches, and a generally reduced quantity of microwear features were observed on the labial and, to a greater extent, on the lingual dentine. Some of these occurrences may be attributed in part to the to normal masticatory functions of the teeth, which, in the case of the incisors, are biting or cutting. The exposed dentine, which is relatively soft compared to enamel, would thus come into contact with varying textures of food, including gritty substances such as Egyptian bread, as well as softer substances such as fruit, both of which would contribute towards the pitting and general obliteration of features on the dentinal surface (Boyde 1984; Teaford 1988a). Further removal of surface features may be the result of erosive processes. It has been demonstrated that acidic foods and beverages (such as fruit or wine) can have a pronounced erosive effect on the teeth. Potential rates of erosion may range from one micron per week to one micron per minute (Davis and Winter 1977; Teaford 1988a; Xhonga et al. 1972). Although acidic citrus fruits were unknown in ancient Egypt, figs, dates, grapes and wine were all fixtures of the Egyptian diet (White 1989), and may have contributed to the erosion and resulting reduction of microwear features on the teeth.

Mandibular Left First Molar

The mandibular left first molar displayed both oblique buccal and flat CEJ wear. The tooth was worn obliquely in a lingual to buccal direction (lingual edge highest), with a completely obliterated buccal enamel rim. A rounded edge remains, which extends down towards the root, forming two polished facets side-by-side at the cemento-enamel junction (Plate 6.13). Associated teeth included the mandibular LM2 and the maxillary LM1, both of which were broken and thus unobservable; and the mandibular LPM2, which exhibited some mesio/distal wear and enamel polishing.

Micrographs of the wear facets revealed a much lower concentration of microwear features than was observed in the two previously described maxillary teeth. Plate 6.14 illustrates both the wear facets and the occlusal rim, the latter indicated by the increasingly bright area near the top of the photo. The short, deep, diagonal gouges along the rim are inconsistent with the wear observed on the rest of the facet. They are quite small, isolated, and do not appear in a regular pattern, all of which suggests that they are the result of postmortem damage (Teaford 1988a). The overall view at this magnification does not reveal any clear striations along the facet or any preferential direction in the wear. Examination of the exposed dentine on the CEJ facet at a higher magnification (Plate 6.15) again shows a paucity of microwear features. A few obvious horizontal scratches are noted, and close examination of the micrograph reveals several shallow, fine striations that angle both vertically and obliquely. Quantification analysis of this area revealed that although the predominant angle of wear striations was vertical, it was closely followed in frequency of occurrence by both horizontal and obliquely angled scratches (Heidler, unpublished manuscript).

The microwear features of the CEJ facets on this tooth are demonstrably quite different from the CEJ microwear observed on the maxillary lateral incisor. It is therefore likely that the wear on each tooth was caused by different activities. A posterior wear pattern similar to those observed on the molar was also observed among Maori and Moriori skulls, and was attributed to the tipping and dislocation of the posterior teeth caused by repeated chewing of a reserve mass of food kept pressed in the cheek (Taylor 1963). Ethnographic accounts of quid chewing among Aborigine and Yuendumu groups have linked the practice to both oblique buccal and oblique mesio/distal wear, and specify that the rounded enamel rim was the result of the quid pressing out against the cheek, where it would be frequently squeezed against the buccal surfaces of the teeth to extract the juices (Barrett 1977). The use of masticatories was widespread in ancient Egypt, and was practiced by individuals from both sexes and all social classes (Dixon 1969; Kennedy et al. 1986). Specific mention of the practice among females is made in the Ebers Papyrus, which describes how women mixed resins and honey to form small pellets which they chewed to sweeten their breath (Dixon 1969). Although the Egyptians utilized a wide variety of substances for their masticatories, including roasted watermelon seeds, ladanum, rush-nut, cinnamon, and honey (Ghalioungui 1973; Kennedy et al. 1986), the substance most frequently used for this purpose was the papyrus plant, which was chewed in both raw and cooked forms.

The SEM analysis also supports the possibility that quid chewing caused the wear, as the continuous pressure against the teeth from the presence of a quid would certainly in time cause enamel abrasion without pronounced microwear striations, because the main action involved would be simply squeezing the mass against the teeth. In addition, the wear observed on the adjacent PM2 further supports the quid-chewing hypothesis. Oblique mesio/distal wear of the posterior mandibular premolar teeth probably resulted from the repeated holding of a foreign substance (such as a quid) between these teeth, resulting in the gradual abrasion of the tooth surface to accommodate this substance. Furthermore, papyrus is a plant which absorbs high amounts of silica from the soil and stores it in the form of concretions of amorphous silica called opal phytoliths (Puech et al. 1983). It has been demonstrated that these phytoliths polish enamel but scratch dentine (Puech et al. 1983; Walker et al. 1978), which would account for both the polishing observed on the mandibular LPM2 as well as the scratches observed on the exposed dentine of the molar. It is therefore highly probable that the wear observed on this molar was the result of the chewing of papyrus masticatories.

CONCLUSION

The study of activity-induced dental abrasion in 5MB12 has revealed several interesting examples of unusual wear patterns, including flat CEJ wear, saddle-shaped wear, and oblique buccal wear. It also revealed some of the complexities involved in determining etiological factors for dental abrasion, as past behaviors are not always represented among modern peoples. Thus the widest possible range of sources were relied upon to aid interpretation and analysis, including macroscopic, microscopic, ethnographic, and archaeological evidence. These sources revealed that the flat CEJ wear observed on the left maxillary lateral incisor was predominantly horizontal in orientation. Although a definite cause for this wear was not identified, some possible explanations included the processing of fibre and sinew, and excessive toothbrushing. Saddle-shaped wear, a unique occurrence within the sample, was found to exhibit horizontal striations labially, and oblique/vertical striations lingually. This is attributed to the possibility that more than one activity was involved in the formation of the wear. It is hypothesized that the saddling effect was the result of hide processing techniques that involved pulling animal skin between the teeth in an outward and upward motion, or of reed and papyrus splitting activities that utilized the incisors as a wedge. The labial wear could be the result of an activity such as stripping reeds or papyrus for weaving, which superimposed horizontal striations upon the already worn labial surface. The oblique buccal and flat CEJ wear observed on the left first mandibular molar is attributed to the chewing of papyrus masticatories, which would account for the obliteration of the enamel rim, the lack of directionality and density in the microwear features, and the associated oblique mesio/distal wear and enamel polishing present on the adjacent LPM2.

Ideally, each tooth in the entire dentition should be examined under the SEM to provide the clearest possible picture of the wear processes that affected the teeth. Future research should concentrate not only upon obtaining the most data possible from microscopic technology, but also on documenting tooth-tool use in modern ethnographic groups and the associated wear patterns. Re-examination of the dentitions from the numerous Egyptian skeletal samples that have been recovered over the last century should also be conducted with the specific purpose of locating and recording other instances of unusual dental abrasion, which would further illuminate the past activities of these ancient people.

Table 6.1.
Wear Type Frequencies in Specimen 5MB12

	Frequency	
Wear Type	# of affected teeth/ total # of observable teeth	% of teeth affected
Interproximal	1/22	5
Oblique Lingual	1/22	5
Saddle-shaped*	2/22	9
Oblique Lab/Buc.	1/22	5
Oblique M/D	1/22	5
Flat Facial*	6/22	27
Flat CEJ*	9/22	41
Flat Root*	1/22	5

* signifies wear unique to this individual
Note: Oblique Lab/Buc. = oblique labial/buccal; Oblique M/D = oblique mesio/distal;
Flat CEJ = flat cemento-enamel junction.

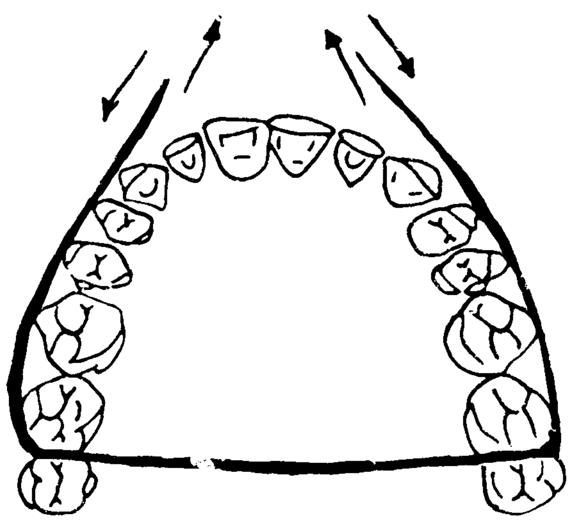


Figure 6.1.
Occlusal view of the dentition, showing
possible mode of cemento-enamel junction wear formation by
fibre or sinew processing.
(adapted from Lukacs and Pastor 1988:388)

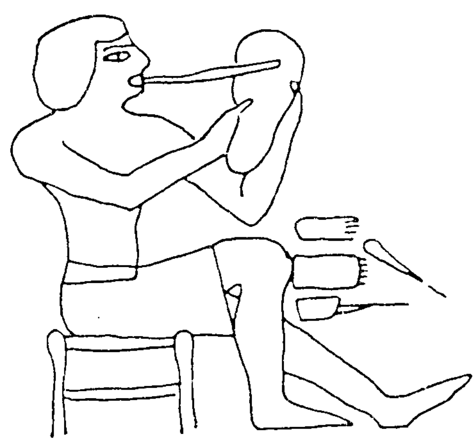


Figure 6.2.
Tomb relief, depicting sandal-making techniques.
(adapted from Montet 1958:154)

Plate 6.1.
Left maxillary lateral incisor, exhibiting Flat CEJ wear. Light microscope photo, original magnification 6.4 x.

Plate 6.2.
CEJ wear facet on LI2, magnification 25 x
(the "crazed" appearance at the lower left
is due to the carbon coating).

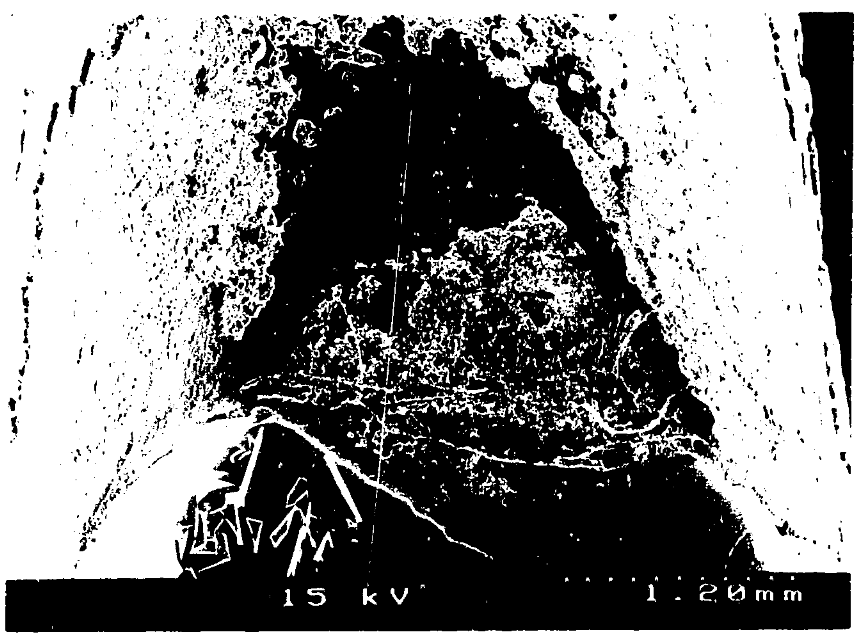


Plate 6.3.
Micrograph of enamel surface of LI2, magnified 25 x.
Apical portion of the tooth is oriented towards
the top right of the photo.

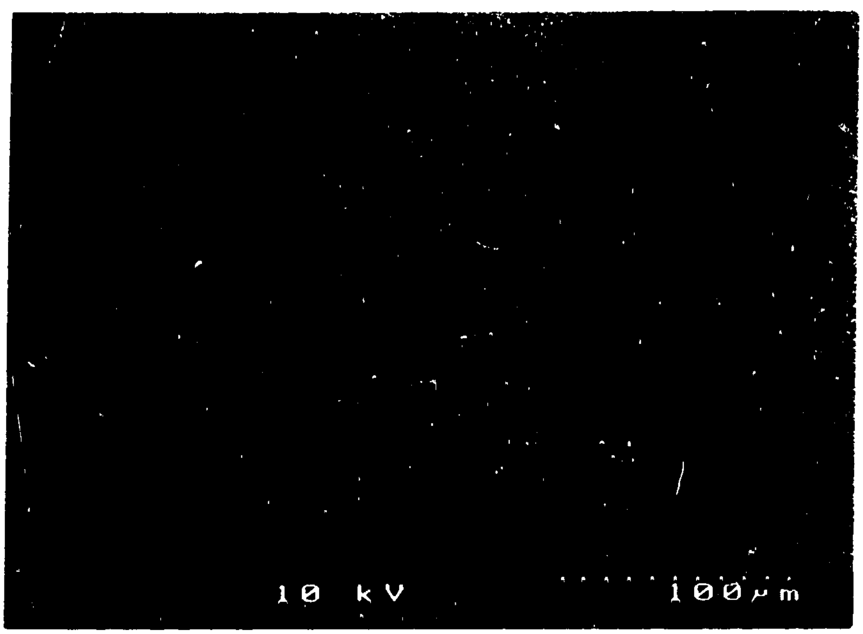


Plate 6.4.
Border between facet and enamel on LI2, magnified 110 x.
(the dark specks are due to dust particles)

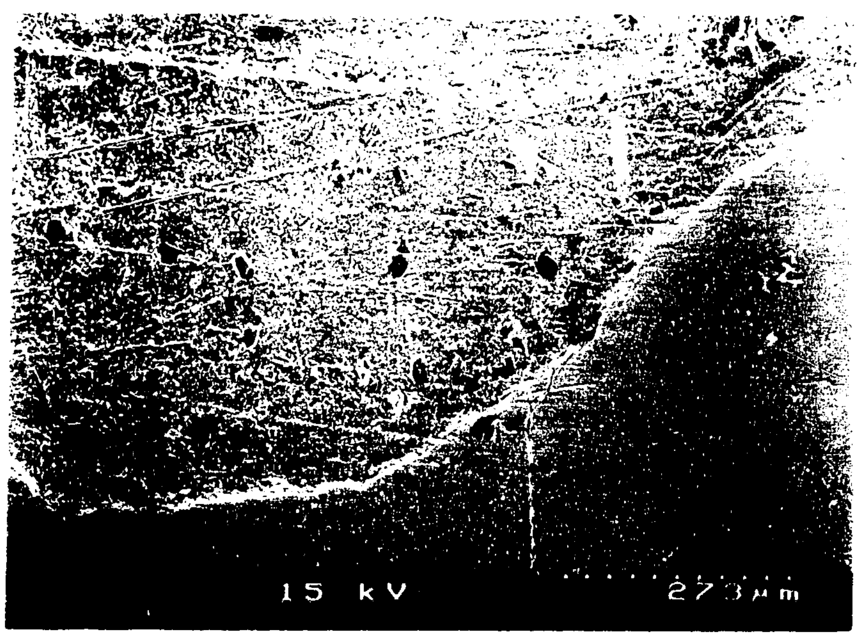


Plate 6.5.
Approximal view of the maxillary central incisor.

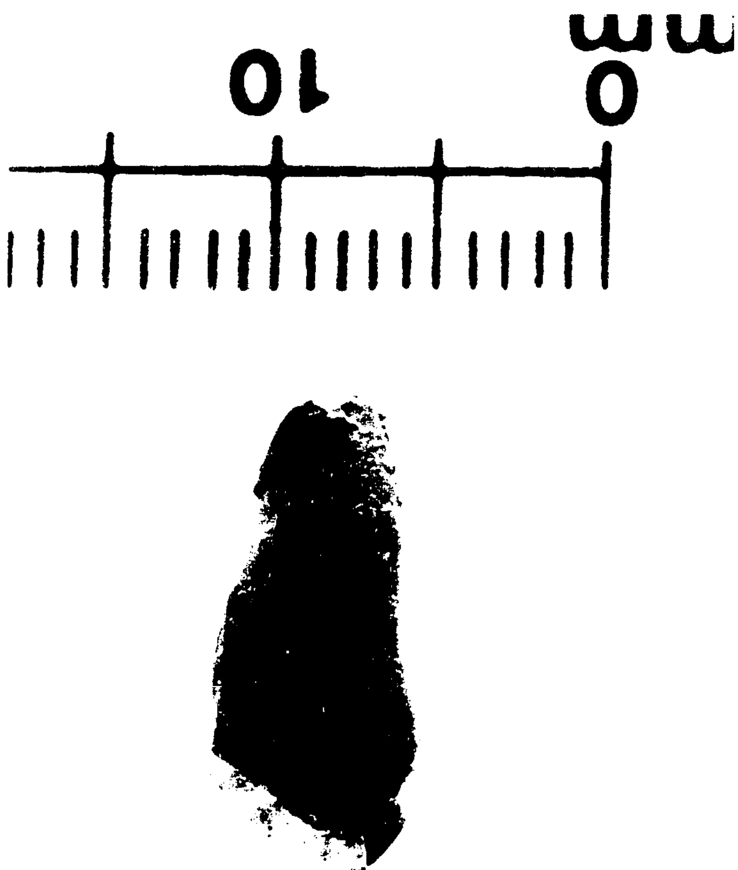


Plate 6.6.
Maxillary central incisor, labial surface,
magnification 25 x.
Apical portion of the tooth is oriented towards the bottom of the photo.

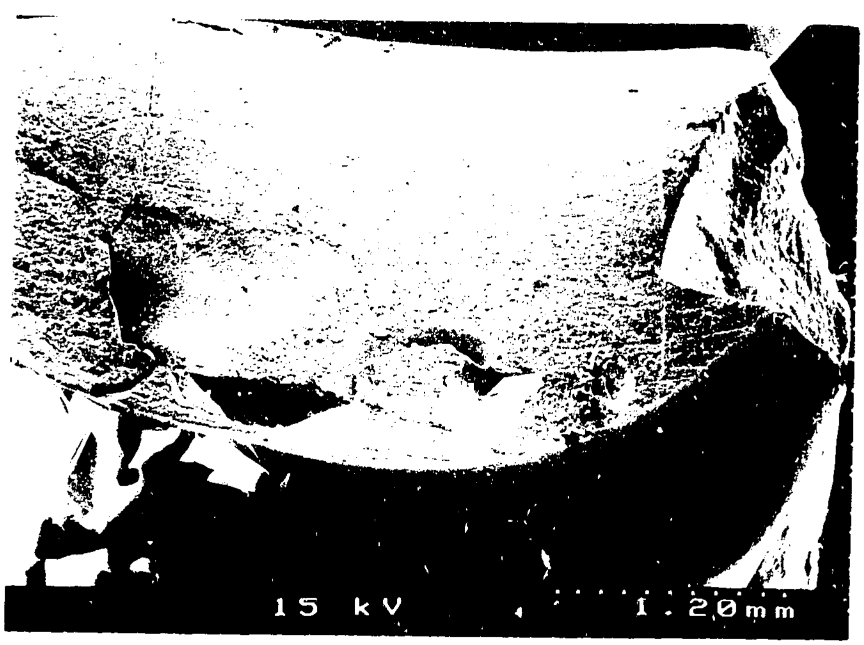


Plate 6.7.
Labial enamel of central incisor,
magnification 250 x.
Incisal edge of the tooth is oriented at the top of the photo.

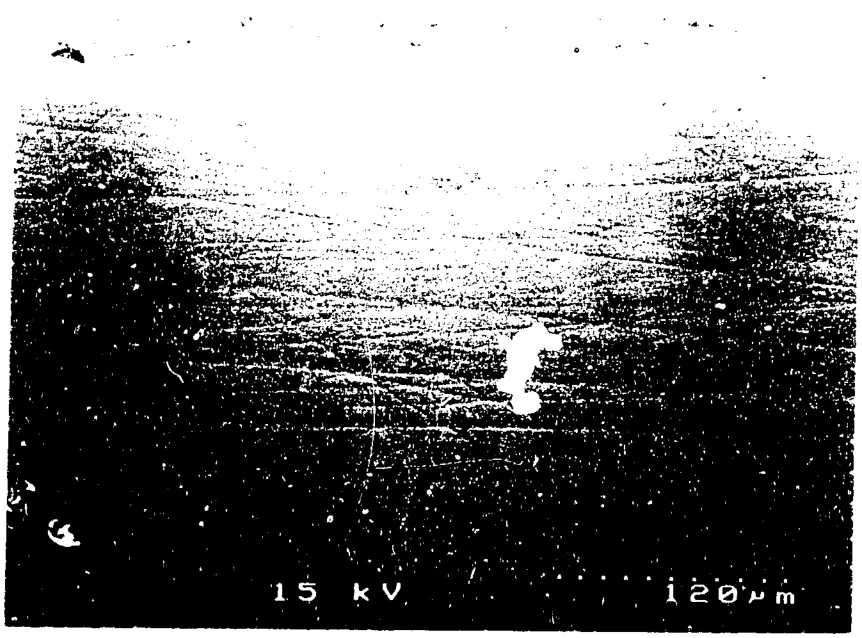


Plate 6.8.
Border between the enamel and the dentine
of I1, magnification 250 x.

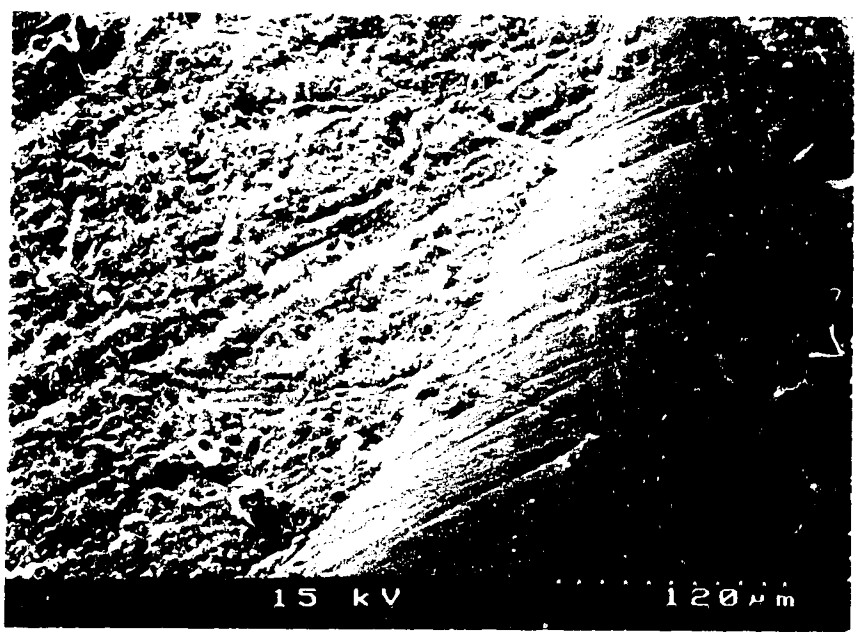


Plate 6.9.
Labial dentine of I1, magnification 110 x.

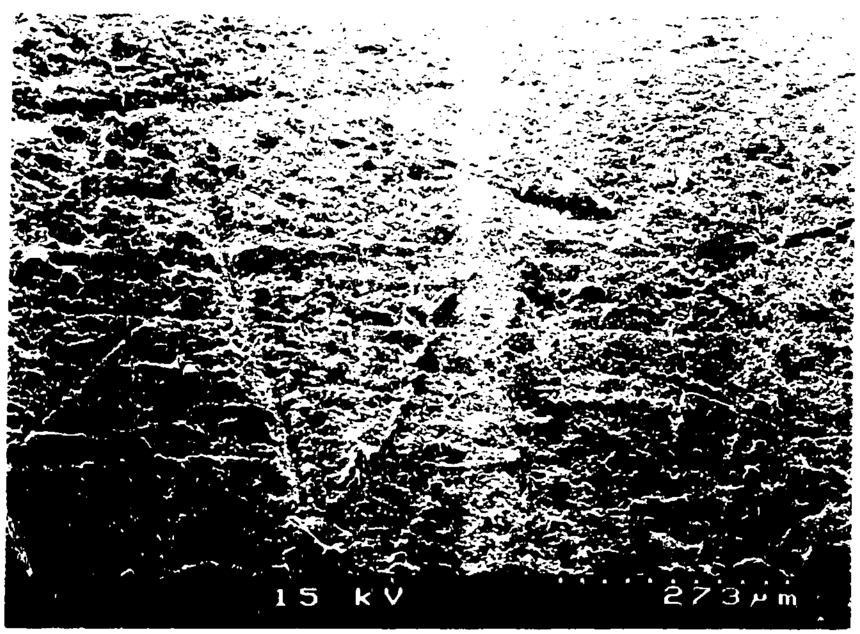


Plate 6.10.
Lingual surface enamel on I1, magnification 150 x.
Apical portion of the tooth is oriented at the bottom of the photo.

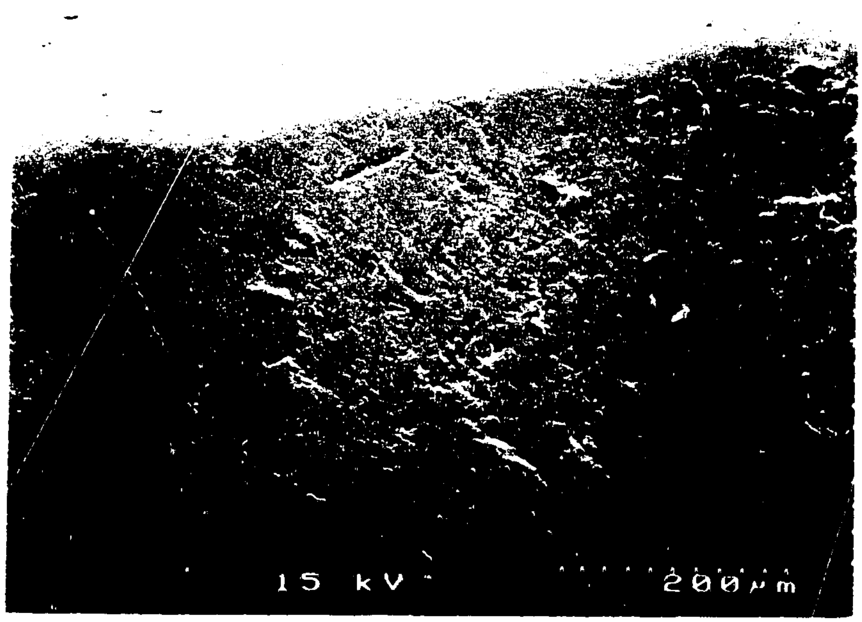


Plate 6.11.
I1 lingual dentine, magnification 110 x.

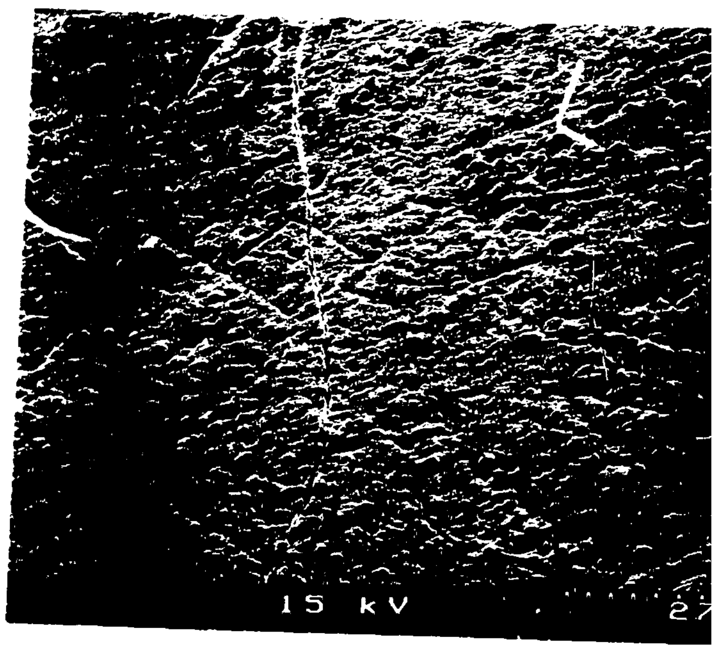


Plate 6.12.
I1 lingual surface and incisal edge,
magnification 60 x.

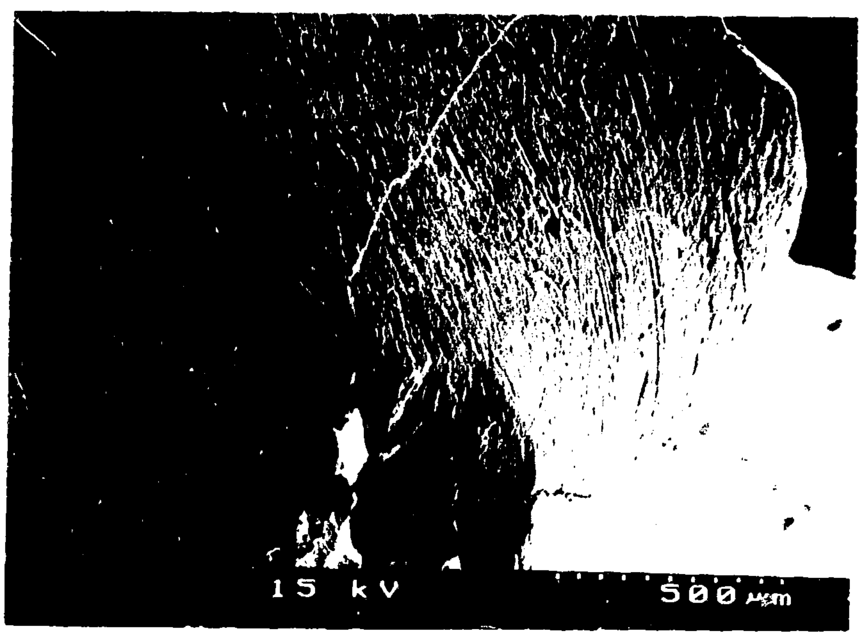


Plate 6.13.
Left mandibular M1, exhibiting CEJ wear
and oblique buccal wear.
Light microscope photo, original magnification 6.4 x.

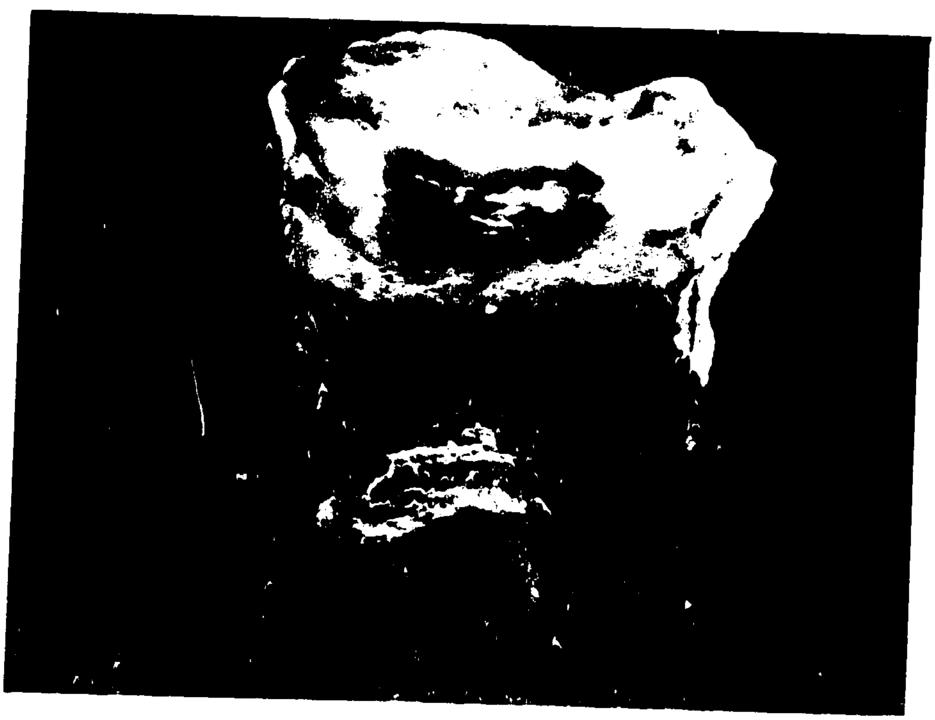


Plate 6.14.
Left mandibular M1: CEJ facet and occlusal rim,
magnification 25 x.
Occlusal surface is oriented at the top of the photo.

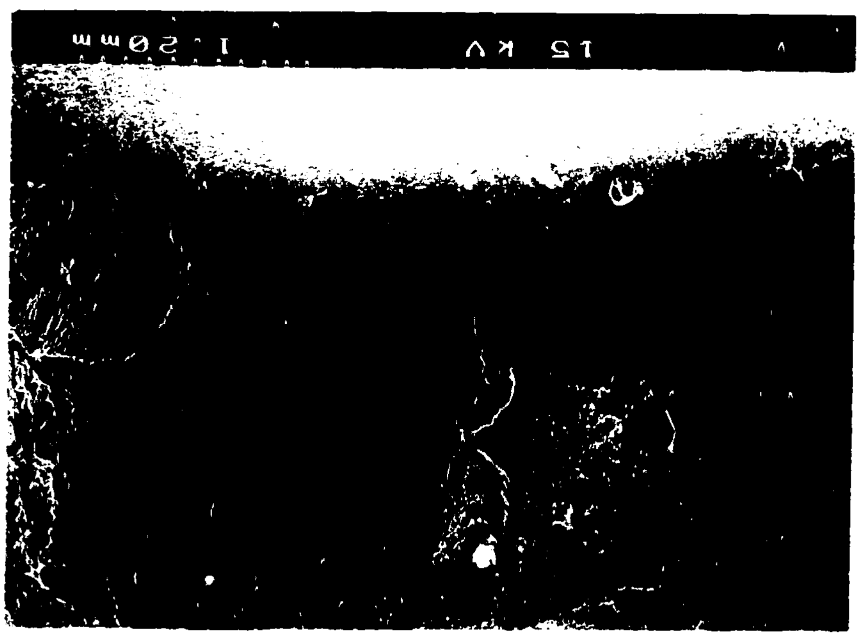
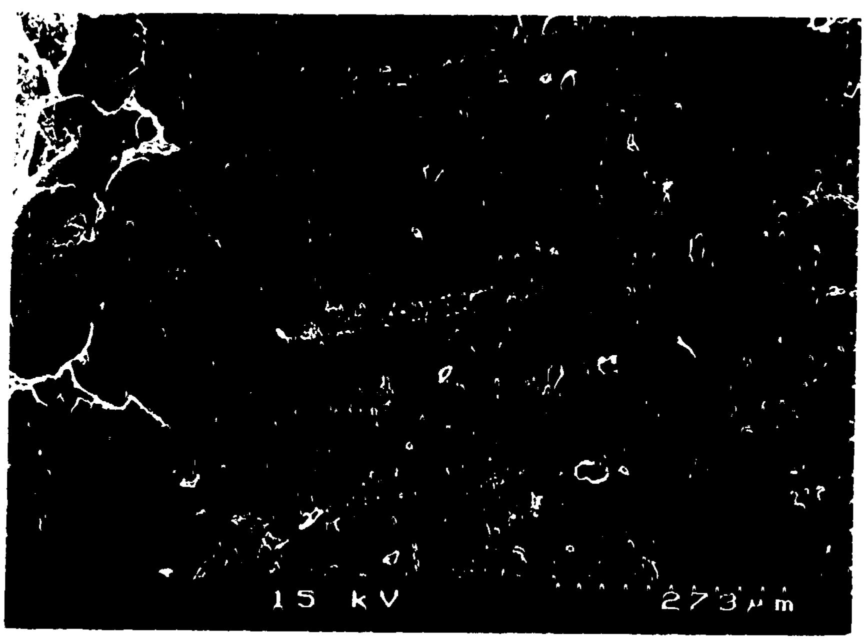


Plate 6.15.
Mandibular left M1: CEJ facet dentine,
magnification 110 x.
Apical portion of the tooth is oriented at the bottom of the photo.



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CHAPTER 7: CONCLUSION

The study of activity-induced dental wear patterns in a skeletal sample from Mendes has revealed that investigations into the dental wear, diet, and activities of ancient peoples can benefit from the use of SEM technology, ethnographic comparisons and archaeological resources such as ancient art, artifacts, and literature. Examination of the dental remains from a sample of twenty-six individuals revealed nine distinct wear patterns, some of which appeared to be unique within the archaeological record. These patterns were: oblique lingual wear, oblique labial/buccal wear, oblique mesio-distal wear, interproximal wear, flat root, facial, and CEJ wear, saddle-shaped wear, and chipping. Of these, the most commonly observed wear patterns were chipping, oblique labial/buccal wear, and oblique mesio/distal wear.

Dental chipping, the most common wear pattern in the sample, exhibited a gradual decrease over the three time periods. This type of wear may be due in part to the chewing of bones as part of the diet, and to recreational activites such as games and sports. A third possibility is that some of the occurrences of chipping were the result of using the teeth to finish flint blade edges, a hypothesis which is supported by the higher frequencies of chipping in men than women during the Old Kingdom and First Intermediate Period/Middle Kingdom. The decreased frequency of chipping over time may be related to a decline in this method of tool preparation and an increased reliance on metal tools in later periods.

Flat wear, which was only observed in the dentition of 5MB12, an adult female from the First Intermediate Period/Middle Kingdom, has been linked to several possible etiological factors, including fibre or sinew processing, splitting reeds for weaving, and horizontal toothbrushing.

Evidence for leather-working practices and skin processing techniques involving the teeth have been provided by the oblique lingual and oblique labial wear of the maxillary and mandibular incisors, as well as by the saddle-shaped wear of two central incisors. Animal skin or hides were likely pulled between the teeth either in a downwards motion, which would have caused the oblique labial/lingual wear, or in an outwards and upwards motion, which could have caused the saddle-shaped effect by wearing away both the labial and lingual surfaces of the enamel.

The practice of quid chewing was also evidenced by the teeth, in the form of oblique buccal wear and a scoop-like form of oblique mesio-distal wear on the posterior teeth. The first of these patterns was the result of tipping or dislocation of the posterior teeth caused by the pressure of the quid between the cheek and the buccal surfaces of the teeth. The second was the result of gradual abrasion of the occlusal surface in order to accomodate the quid.

The incorporation of scanning electron microscopy further aided attempts at interpretation. The teeth of 5MB12, an adult female from the First Intermediate Period/Middle Kingdom, were examined in order to document the microwear features associated with flat CEJ wear, saddle-shaped wear, and oblique buccal wear. Flat CEJ wear of a maxillary lateral incisor was found to display predominantly horizontal microwear features, which is consistent with toothbrushing or reed stripping activities.

Saddle-shaped wear, which was a unique occurrence within the sample, was found to exhibit horizontal striations labially, and oblique/vertical striations lingually. This is attributed to the possibility that more than one activity was involved in the formation of the wear. It is likely that hide processing or use of the teeth as a wedge to split reeds caused the saddle-shaped wear, and that an activity such as toothbrushing or reed and papyrus stripping superimposed horizontal microwear on the already worn labial surface. The oblique buccal and flat CEJ wear observed on a mandibular molar is attributed to the chewing of papyrus masticatories, which would account for the obliterated enamel rim, the lack of directionality and density in the microwear features, and the associated oblique mesio-distal wear and enamel polishing on the adjacent premolar.

Future research into patterns of activity-induced dental abrasion should include a detailed compilation of non-masticatory uses of the teeth in modern populations, which would facilitate ethnographic comparisons between archaeological and living groups. A systematic examination of the various collections of Egyptian skeletal material should also be conducted in order to locate and record other instances of unusual dental wear. The vast quantity of Egyptian skeletal material that is available for study would make an undertaking such as this extremely informative, for it would allow for more detailed statistical comparisons to be conducted upon larger samples. This would, in turn, provide us with information about the patterns of distribution and change of occupational dental wear, which could then be related to changes in behavior.

Finally, continued refinement of SEM techniques for the examination of fragile archaeological specimens is recommended. Improvements in casting or coating techniques are necessary in order to provide the clearest possible image with the least possible damage to the tooth.