7. DENTAL HEALTH AND CHARACTERISTICS

7.1 Introduction

Dental anthropology is a broad field of study that encompasses the study of the development, anatomy, morphology, and diseases affecting teeth (Hillson 1986; 1996; Lukacs 1995; Roberts and Manchester 1995; Aufderheide and Rodriguez-Martin 1998). Because of the complex organic and inorganic structure of teeth, they tend to preserve and last much longer in archaeological deposits than bones. There are abundant amounts of information that can be derived from teeth such as oral health, diet, as well as nutritional and bacterial stress experienced during early developmental ages (Lukacs 1995; Roberts and Manchester 1995). This chapter is divided into four main sections namely, dental pathology, dental wear, odontometric characteristics and dental modification.

7.2 Dental pathology

The study of dental palaeopathology is a specialized field focused on ancient dental diseases (Lukacs 1989; Goodman and Rose 1990; 1991; Larsen et al. 1991; Roberts and Manchester 1995; Aufderheide and Rodriguez-Martin 1998). Dental palaeopathology has become increasingly important over the years (Ortner and Putschar 1981; Roberts and Manchester 1995; Lukacs 1995), owing to the fact that it provides data on both diet and dental health of skeletal populations. A strong relationship between diet and dental health has long been recognised (Lukacs 1989; Walker and Hewlett 1990; Larsen et al. 1991; Goodman and Rose 1991; Erdal and Duyal 1999) and used to further our knowledge of the lifestyles of ancient populations. For instance, severe nutritional deficiencies during the early years of life cause disturbances on amelogenesis and result in enamel hypoplasia (Ortner and Putschar 1981; Goodman and Rose 1990; 1991; Roberts and Manchester 1995), while dental caries is triggered by high carbohydrate and sugar content in food (Lukacs 1989; 1995 Larsen at al. 1991; Hillson 1991; 1996; 2001). Calculus is known to trap food microscopic elements such as plant phytoliths, which can be used to reveal the most dominant type of food an individual, or group of individuals, had regular access to (Buikstra and Ubelaker 1994). Indicators of oral health are thus used as parameters from which general diet and lifestyles of archaeological skeletal populations can be inferred (Erdal and Duyal 1999).

The role of diet on the prevalence of dental diseases has been studied using skeletal populations of different subsistence strategies and time periods, e.g., Goodman et al. (1980), Walker and Hewlett 1990 and Larsen et al. (1991). A general trend in the results of these various works is that there is a high prevalence of dental caries on populations dependant on agriculture for subsistence, and much dental attrition in hunter-gatherers whose subsistence is based on unrefined foods. Enamel hypoplasias are most common in communities whose food resources are seasonal rather than annual.

Like all other studies based on human skeletal remains, dental palaeopathology is fraught with problems and limitations. Although teeth tend to survive much longer in the archaeological record than bones, they are easily removed from their sockets and can be lost. Postmortem tooth loss and tooth damage are common problems in archaeological cases. Anterior teeth are the most susceptible to destructive post-depositional processes (Ortner and Putschar 1981; Buikstra and Ubelakar 1994; Roberts and Manchester 1995) because their single root structure does not offer resistance to processes acting upon them. Posterior teeth have multiple roots whose morphology makes it difficult for them to be dislodged. Both postmortem and antemortem tooth losses are problematic because they lead to loss of information regarding the pathological status of lost teeth.

Antemortem tooth loss may be pathologically or culturally induced (Ortner and Putschar 1981; Lukacs 1989) but unfortunately it is not always easy to differentiate between the possible reasons for antemortem tooth loss when dealing with archaeological skeletons.

Another problem is that dental disease can result in very large lesions or total crown destruction, thereby erasing any evidence of earlier lesions caused by other diseases. For instance, severe dental wear or attrition, especially common in archaeological remains, erases evidence of other dental pathologies that could have been recognised from the eroded enamel such as dental caries, calculus and enamel hypoplasia. Both dental wear and dental caries can result in total crown destruction in which only the root remains. At this point it becomes difficult to differentiate between these diseases especially when only macroscopic visual observation is the only method used.

7.2.1 Dental caries

Dental caries, also known as dental decay, is a pathological process in which the hard outer tissues of teeth are destroyed (Ortner and Putschar 1981; Lukacs 1989; Henneberg 1991; Roberts and Manchester 1995; Aufderheide and Rodriguez-Martin 1998). The process through which a tooth decays depends on a variety of external factors such as oral hygiene and diet as well as the morphology of the tooth itself. For instance, it has been noted by various anthropologists that anterior teeth have less prevalence of dental caries than posterior teeth (Buikstra and Ubelakar 1994; Erdal and Duyar 1999; Hillson 2001). This is because posterior teeth have fissures and crevices within which bacteria and its associated chemicals can easily attach to the tooth. Dental caries is a progressive infectious disease caused by bacterial organisms (Lukacs 1989; Aufderheide and Rodriguez-Martin 1998). Some authors have suggested a genetic predisposition to dental caries.

Different theories have been proposed with regard to conditions necessary to trigger the development of dental caries. Chemicals, parasitic bacteria and acids in the oral cavity have been found to be the most dominant predisposing factors (Ortner and Putschar 1981; Lukacs 1989; Henneberg 1991; Hillson 1996; Aufderheide and Rodriguez-Martin 1998). Sucrose and acidogenic bacteria combine and cause the dissolution of the inorganic matrix through decalcification and demineralization. This is followed by the disintegration of the organic matrix. The end result is cavitation of the tooth (Lukacs 1989; Henneberg 1991; Hillson 1996). Dental caries are differentiated on the basis of the tooth area affected, for example, crown caries and root caries (Ortner and Putschar 1981; Hillson 1996; 2001; Aufderheide and Rodriguez-Martin 1998). Crown caries are common across all ages, while root caries tends to be associated with older individuals with a history of periodontitis.

Dental caries have been reported in all parts of the world and throughout all time periods (Ortner and Putschar 1981; Roberts and Manchester 1995; Aufderheide and Rodriguez-Martin 1998). It affects individuals of all races, sexes, ages and social levels. Several authors (e.g., Lukacs 1989; 1996; Henneberg 1991; Larsen et al. 1991) have attributed the marked increased in the prevalence of dental caries during the last several centuries to the development of agriculture. The increase in carbohydrate and sucrose content in diet increased the chances of dental caries. Larsen and coworkers (1991) studied four population groups in the southeast Atlantic coast of the USA. The groups were differentiated on the basis of their mode of subsistence and the results indicate a general increase in the incidence of dental caries with the development of agriculture and early contact with Europeans (Larsen et al. 1991). Dental caries rates provide valuable information regarding the adaptation of past populations to the physical and cultural environment (Erdal and Duyar 1999).

The observed caries rate (the percentage of teeth with caries) is regarded as less accurate indicator because it does not account for antemortem tooth loss which may have been a result of dental caries. In order to eliminate this shortcoming, correction procedures for calculating dental caries are employed (Lukacs 1992; 1995; 1996; Erdal and Duyar 1999). One such procedure is the decayed-and-missing teeth index. The decayed-and-missing teeth index assumes that all teeth missing antemortem are a result of dental caries. Although the method overrules other factors as being responsible for antemortem tooth loss especially in archaeological skeletons, it may not necessarily lead to critical inaccuracies in results obtained particularly where the prevalence on antemortem tooth loss is low. Erdal and Duyar (1999) have proposed a slightly different correction procedure for calibrating dental caries. Their procedure involves the separation of anterior teeth (incisors and canines) from posterior teeth (premolars and molars) so as to calculate dental caries rates on the basis of the ratio of anterior to posterior teeth. Posterior teeth are more prone to dental caries than anterior teeth and the method proposed by Erdal and Duyar (1999) takes this factor into account.

Methods

Visual observation was done on all surfaces of each tooth. Carious lesions were recorded in terms of their location on the tooth and a scoring system was used for the size of lesions found. The lesions were divided into small, moderate and large. Small lesions were mostly small pits and moderate lesions were those affecting approximately one-fourth of the tooth surface. Large lesions included those in which at least half of the crown height had been destroyed and thereby creating deeper cavity.

Two different caries rates were calculated, the 'observed caries rate' and the 'decayed-and–missing index' (Lukacs 1995; 1996; Erdal and Duyar 1999). The 'observed caries rate', also known as caries intensity, is the number of teeth with caries expressed as a percentage of the total number of teeth observed. The corrected caries rate, using the decayed-and-missing teeth index, is the sum of teeth with carious lesions and teeth missing antemortem expressed as a percentage of the sum of teeth observed and those teeth lost antemortem (Lukacs 1996). Caries frequencies were calculated for deciduous, permanent and combined samples. Caries frequency shows the percentage of individuals with carious lesions on one or more teeth. Assessment for dental caries included 587 permanent teeth and 193 deciduous teeth. Twenty-four permanent teeth were excluded because of post depositional damage, which had made them unobservable.

Results

Dental caries was identified on 23 teeth; 20 permanent and three deciduous. Permanent teeth affected include two central incisors, one first premolar, one second premolar, three first molars, seven second molars and four third molars and the two unidentified molars. Table 7.2a and Table 7.2b show the distribution of dental caries on various permanent and deciduous teeth respectively. The 20 permanent teeth with carious lesions came from eight individuals (Thataganyane Hill Burial 1, Taukome Burials 1 and 2, Bosutswe Burials 3, 5 and 12; Toutswemogala Burial 16 and Kgaswe B-55 Burial 14).

In the case of deciduous teeth, a canine, a first molar and a second molar were affected. The teeth are from Bosutswe Burial 6 and Toutswemogala Burial 6. The individuals affected ranged between about six years (Bosutswe Burial 6) and 75 years (Bosutswe Burial 12).

Table 7.1a shows that on permanent teeth, dental caries occurred more frequently on posterior teeth than on anterior teeth. Two premolars and 16 molars had been involved while only two central incisors show small carious lesions. Posterior teeth are more susceptible to dental caries because of their surface morphology allows for bacteria to attach to them easily.

Carious lesions found ranged in size between small pits to large cavities, which had eroded most of the tooth crown (e.g., the lower right second molar of Taukome Burial 2 and the upper right second molar of Bosutswe Burial 5). The number of teeth involved per individual ranged between one tooth (e.g., Taukome Burials 1 and 2 and Toutswemogala Burial 6) and six teeth (e.g., Kgaswe B-55 Burial 14).

Observed caries rates or caries intensity of permanent teeth as well as deciduous teeth were calculated (Lukacs 1995; Erdal and Duyar 1999). The same calculation was also performed on pooled deciduous and permanent teeth and the results are shown in Table 7.2. Caries intensity is greatest on permanent teeth by comparison to deciduous and combined samples of permanent and deciduous teeth. Deciduous teeth show the least caries intensity.

Table 7.1a Distribution of dental caries on permanent teeth.

Tooth	Number of teeth	Affected	Percentage
I1	59	2	3.39
I2	69	0	0
C	81	0	0
PM1	78	1	1.28
PM2	74	1	1.35
M1	104	3	2.88
M2	76	7	9.21
M3	44	4	9.09
Unidentified	2	2	100
Total	587	20	

Table 7.1b Distribution of dental caries on deciduous teeth

Tooth	Number of teeth (n)	Carious	Percentage
i1	27	0	0
i2	30	0	0
c	35	1	2.86
m1	50	1	2.00
m2	51	1	1.96
Total	193	3	

Table 7.2 Summary of caries intensities of Toutswe sample

	Number of teeth (n)	Carious	Intensity (%)
Deciduous	193	3	1.55
Permanent	587	20	3.41
Pooled	780	23	2.95

Seven permanent teeth (five first molars, a second molar and a third molar) from four individuals had been lost antemortem. All of these individuals had carious lesions on some of their remaining teeth. Taukome Burial 2 had lost three mandibular molars Unfortunately the maxilla and its teeth had not been preserved. Kgaswe B-55 Burial 14 had lost both lower first molars and was the most affected by dental caries with six teeth involved. Taukome Burial 1 and Bosutswe Burial 12 had each lost a first molar.

The seven teeth lost antemortem were used to calculate a decayed-and-missing index. Although the true underlying factors responsible for these losses are unknown, an assumption that they were lost due to dental caries was made on the premise that all of them had been lost on individuals with carious lesions on some of their preserved teeth. A corrected dental caries rate or intensity based on the decayed-and-missing index of permanent teeth was calculated as follows:

$$\text{Decayed-and-missing index} = (20+7)/ (587+7) \times 100 = \underline{4.55\%}$$

The decayed and missing index still shows a low corrected caries rate of only four and half percent. Subsequently, the caries frequency was calculated. The total number of individuals assessed was 46 and 10 of then had carious lesions. The caries frequency was therefore 21.74%.

$$\text{Caries frequency} = 10/46 \times 100 = \underline{21.74\%}$$

A comparison of both caries intensity and caries frequency between Toutswe and other skeletal populations is shown in Table 7.3. The data used in this table is for permanent teeth only. Comparison of caries incidence should ideally be done at the caries frequency level where the comparison is based on number of individuals affected. This is because caries intensity is biased in the sense that the number of carious teeth varies from one individual to the other. Unfortunately it is not always possible to find the number of individuals included in the sample, as some authors are more interested in caries intensity than caries frequency. The Toutswe sample included in this table consists of 26 adults with one or more permanent teeth. They are aged between 20 and 75 years old.

The samples included in the comparison come from both archaeological and modern populations. These included K2/Mapungubwe, Oakhurst, Kakamas and Riet River, Kalahari San and Aka. The Aka people are a modern agriculturalist population in central Africa (Walker and Hewlett 1990). They have been selected as an outlier from a different geographical area and with a different subsistence. Oakhurst is a pre-pastoral group, Kakamas, and Riet River samples represent pastoral communities (Morris 1984; 1992; Patrick 1989; Sealey et al. 1992). The Kalahari San are a modern population dependent mostly on hunted and gathered terrestrial resources (Van Reenen 1964c). Historic communities at Griqua, Colesberg and Wolmaransstad show relatively low caries intensities (Peckmann 2002). The historic communities were included in this comparison as outliers from a more recent time period.

Table 7.3 shows a very high caries intensity and frequency in the Oakhurst sample (17.7% and 84.6% respectfully) by comparison to others. The Oakhurst people were dependent on marine and terrestrial food. Although diet plays a role, the high incidence of dental caries in the Oakhurst sample has been attributed to extremely low fluoride content in the underground water and diet (Patrick 1989; Sealy et al. 1992). The Kalahari San, on the other hand, have a low caries intensity and frequency attributed to sufficient fluoride content in water (Van Reenen 1964c; Sealy et al. 1992). Fluoride is a halogen compound that protects teeth from invading bacteria. Another factor for the low caries rates on the Kalahari San is their diet, which has high fiber content and is thus less cariogenic (Van Reenen 1964c).

The Toutswe people are the third least affected by dental caries, with an intensity of 3.41% and frequency of 21.74%. By comparison to both archaeological and modern agriculturalist samples, i.e. K2/Mapungubwe and Aka, the Toutswe sample is the least affected by dental caries. When compared to all archaeological samples regardless of the mode of subsistence, they are the second least affected. Unfortunately, not much is known about fluoride content of underground water surrounding the Toutswe area. The sites themselves are distributed over a vast area and therefore the fluoride content may have varied from one place to other. Evidence in the form of carbonized sorghum grains and millet (Denbow 1982; 1983a; Reid 1998) gives an indication of some of the cereals exploited by these people.

Table 7.3 Caries intensities and frequencies on permanent teeth from various populations

Sample	Caries intensity			Caries frequency			Source
	teeth (n)	carious teeth	I (%)	individuals (n)	affected individuals	F (%)	
Toutswe	587	20	3.41	46	10	21.74	This study
K2/Mapungubwe	306		18.3		56	54.5	Steyn 1994
Oakhurst	192	34	17.7	13	11	84.62	Sealy et al. 1992
Kakamas	989		1.3	42.5		18.8	Morris 1992
Riet River	1061		4.3	46.5		41.7	Morris 1992
Kalahari San*	11521	79	0.69	406	37	9.11	Van Reenen 1964c
Aka*	3099	163	5.17	110			Walker & Hewlett 1990
Griqua[!]	1101	32	2.9				Peckmann 2002
Colesberg[!]	1067	41	3.8				Peckmann 2002
Wolmaransstad[!]	522	29	5.6				Peckmann 2002

* Modern community

[!] Historic community

I (%) caries intensity

F (%) caries frequency

7.2.2 Calculus

Calculus, also commonly known as tartar, is mineralised plaque (Ortner and Putschar 1981; Hillson 1986; 1996; Roberts and Manchester 1995). Dental plaque, which contains microorganisms, accumulates in the mouth and attaches to enamel. If not removed regularly, crystallites are deposited on top of living plaque to form what is eventually found as hard calculus (Roberts and Manchester 1995; Hillson 1996). Teeth surfaces closest to the salivary glands are the most susceptible to calculus formation. Such surfaces are lingual surfaces of anterior teeth and buccal surfaces of molars (Lukacs 1989; Roberts and Manchester 1995; Hillson 1996). Calculus is associated with infection of the gingivae on areas where deposits are made (Van Reenen 1964c).

There are two types of calculus, supragingival and subgingival. Supragingival calculus attaches to the enamel or above the gums. This type of calculus is usually thicker with a rough surface and is cream or brownish in colour. Subgingival calculus is deposited on the root surface of the tooth, thinner but harder than supragingival calculus and lighter in colour (Hillson 1996). The most commonly found calculus in archaeological skeletons is supragingival. It may be easily lost after deposition or during analysis if not treated with caution.

Deposits of calculus may give a reflection of oral hygiene since they result from oral debris that is not cleaned off. Calculus has been used in reconstructing diets of prehistoric skeletons. Microscopic food elements such as plant phytoliths can get trapped and embedded into calculus and thus provide information on individuals and population diets (Roberts and Manchester 1995).

Methods

Deposits of calculus or tartar were recorded as present or absent. A fine, small painting brush was used to brush teeth slightly to check if deposits found were actually hard calculus or fine ash and soil attached to teeth after deposition. Post depositional dirt in the form of ash and soil came off easily using fine strokes on teeth. Hard and well-attached calculus, on the other hand, did not fall of teeth when brushing them finely. True calculus was not cleaned off but scored and left in situ.

Calculus deposits were scored on a scale of one to three. On the least side of the scale were teeth with thin calculus deposits and on the other extreme end were thick deposits covering up to about half the tooth size in some cases. The surfaces where such deposits were found were also recorded. The system used has been borrowed from Brothwell (1981) and has been recommended by numerous authors (e.g., Lukacs 1989; Buikstra and Ubelaker 1994; Roberts and Manchester 1995). In some cases of thick calculus deposits, it was not possible to make an observation of enamel hypoplasia.

Results

A total of 12 individuals had some degree of calculus deposits on some their teeth (Bosutswe Burials 3, 5, 6, 11, 12, 13, Toutswemogala Burial 16, Kgaswe B-55 Burials 2, 9, 16, Swaneng Hill Burial 1 and Thatswane Burial 6). The amount of calculus ranged from thin bands on the labial surfaces only to thick bands covering labial and lingual surfaces. Interproximal calculus deposits were also noted in a few cases. Anterior and posterior teeth were affected almost equally. Three adults and one child had thick deposits on some of their teeth. One child with deciduous dentition had been affected. Although calculus takes time to accumulate, during which deciduous teeth maybe shed, poor oral hygiene and diet may facilitate its rapid buildup even on deciduous teeth. Figure 7.1 shows moderate calculus deposits on mandibular teeth of Bosutswe Burial 12.

Reports of calculus on archaeological skeletons and modern populations are common in all parts of the world. While diet oral chemical have influence on the rate and amount of calculus being deposited, it is possible that calculus in archaeological skeletons may be largely influenced by poor oral hygiene.

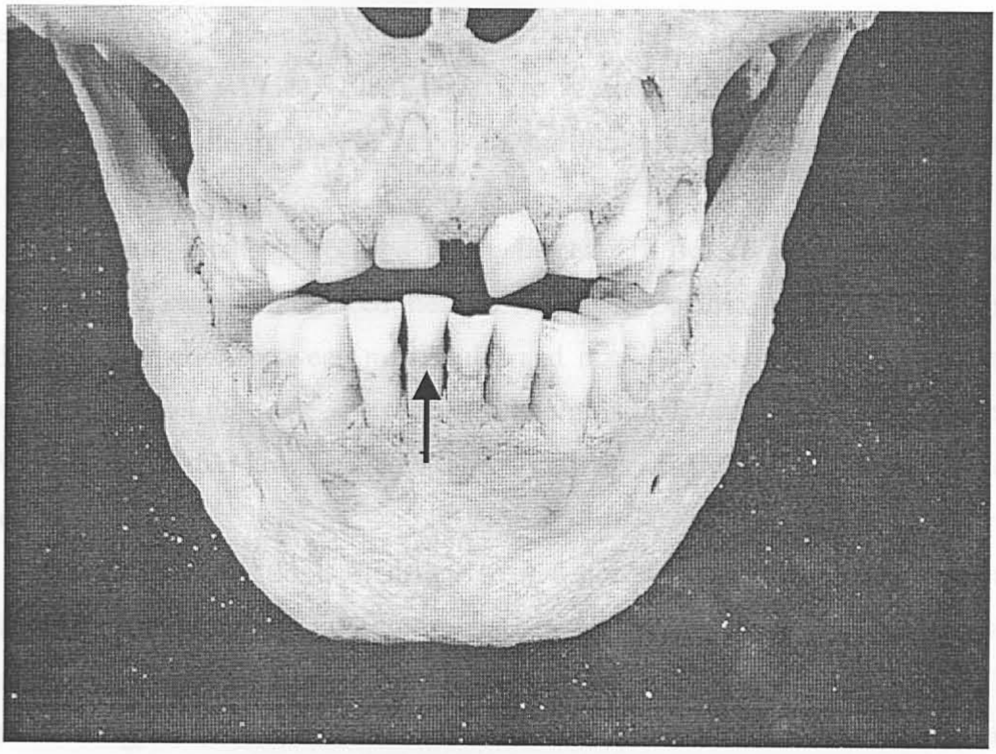
7.3 Dental wear

Introduction

Dental wear is a general term used to refer to any of the progressive conditions that destroys tooth enamel (Molnar 1971; Hinton 1981; Van Reenen 1982; Powel 1985; Roberts and Manchester 1995; Aufderheide and Rodriguez-Martin 1998). There are three such processes, mainly dental attrition, dental abrasion and dental erosion. Dental attrition is the wearing away of tooth enamel as a result of tooth-to-tooth contact during mastication. It is a physiological process associated with age. This process is not pathological but can expose structures underneath the enamel to risks of diseases (Ortner and Putschar 1981; Powell 1985; Roberts and Manchester 1995; Aufderheide and

Rodriguez-Martin 1998). Severe dental attrition can lead to the degeneration of the temporomandibular joints (Brothwell 1981; Richards and Brown 1981; Richards 1990) and, occasionally, the development of tori (Roberts and Manchester 1995). In cases of severe dental attrition, the mandible may be displaced anteriorly thereby resulting in edge-to edge occlusion of incisors (Richards and Brown 1981).

Figure 7.1 Bosutswe Burial 12 with moderate calculus on mandibular teeth



Dental abrasion occurs as a result of friction between the enamel and foreign material introduced to the oral cavity. Abrasive material can be from food or other materials placed regularly in the mouth (Ortner and Putschar 1981; Powell 1985; Roberts and Manchester 1995; Aufderheide and Rodriguez-Martin 1998). Dental erosion is a process in which chemicals introduced into the oral cavity erode the enamel, without bacterial activity.

Numerous studies (e.g., Molnar 1971; Brothwell 1981 Ortner and Putschar 1981; Powell 1985; Roberts and Manchester 1995; Aufderheide and Rodriguez-Martin 1998) have shown that dental wear can be used as an age indicator in adult skeletal remains within a population, once factors affecting the rate of wear in that population have been assessed. Furthermore, dental wear has been shown to be a good indicator of differences in food acquisition procedures between males and females within a population and also across populations. For example, Hinton's (1981) study of numerous dentitions from four aborigine groups has revealed differences in dental wear between sexes and populations as a result of cultural practices, which govern the use of teeth. Other studies by Van Reenen (1964a; 1964b; 1964c; 1982) have also revealed the role played by cultural division of labour in determining the rate, type and form of dental wear on the Kalahari San.

Dental wear results in reduced crown height if it occurs on occlusal surfaces. Interproximal wear results in reduced mesiodistal length. Occlusal wear is often a result of tooth-to-tooth friction between mandibular and maxillary teeth. During mastication movement of teeth on the same jaw results in interproximal wear (Ortner and Putschar 1981; Van Reenen 1982; Powell 1985; Roberts and Manchester 1995; Aufderheide and Rodriguez-Martin 1998).

The magnitude and form of dental wear depends on a variety of intrinsic and extrinsic factors (Hinton 1981; Van Reenen 1982). Intrinsic factors include the size, shape, form and quality of enamel as well the position of the tooth on the mouth. The amount of energy used for mastication can also influence the rate of dental wear. Previous studies have shown that incisors are the least resistant to attrition because of their small occlusal surface (Van Reenen 1982). Extrinsic factors include the quantity of abrasives in food, as well as the use of teeth as tools. The habitual use of teeth plays a major role in determining form of tooth wear (Molnar 1971; Hinton 1981). Secondary dentine is formed to replace that which had been destroyed by attrition and abrasion. However, the rate of dentine destruction may be much faster than the rate for secondary dentine formation and in such cases the pulp space is exposed (Van Reenen 1982; Roberts and Manchester 1995; Aufderheide and Rodriguez-Martin 1998).

Dental wear is one of the most commonly reported dental defects in archaeological skeletons from all parts of the world (Molnar 1971; Roberts and

Manchester 1995; Aufderheide and Rodriguez-Martin 1998). It has been found that prehistoric populations suffered more dental wear than modern populations presumably due to high quantity of abrasives in food, use of teeth for other purposes besides chewing, as well as tough food requiring more energy for mastication (Molnar 1971; Van Reenen 1982; Roberts and Manchester 1995; Aufderheide and Rodriguez-Martin 1998). Morphological alterations of teeth as a result of dental attrition, abrasion or erosion are macroscopically similar. However, dental abrasion can be identified by the presence of microscopic groves or pits on enamel whereas dental attrition produces smoothly worn surfaces (Roberts and Manchester 1995).

One of the most commonly identified forms of tooth wear in archaeological skeletons is 'cupped wear' or a concave surface in which the dentine level recedes below the enamel level (Molnar 1971; Hinton 1981). This occurs because dentine is softer and wears much faster than enamel. Wear type is the angle formed on the occlusal surface as result of attrition (Molnar 1971).

Methods

Dental wear was recorded on all deciduous and permanent teeth with preserved crowns. The scoring was divided on a scale of zero to seven (Brothwell 1981). A score of one was allocated to teeth whose occlusal surfaces showed no signs of attrition, while a score of two was for surfaces showing slight polishing but with occlusal surfaces still showing all of its morphological features. Teeth were allocated a score of three if small or medium sized dentine was exposed. A score of four was allocated to teeth with large dentine exposure, but still surrounded by enamel. Teeth with enamel eroded on occlusal surfaces as well as other surfaces were given a score of five. Those with little or no enamel remaining and those with only roots present were scored six and seven respectively (Brothwell 1981).

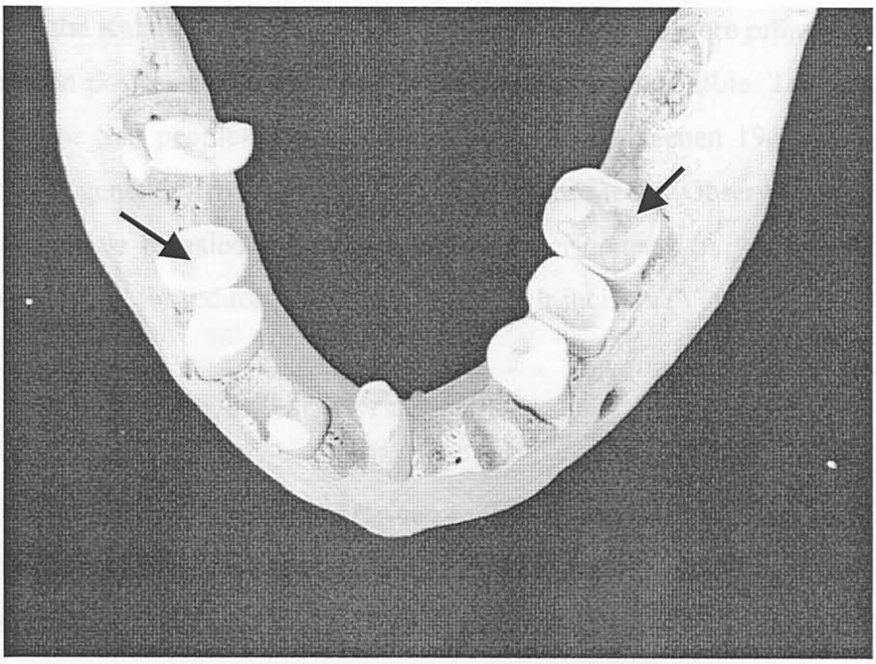
A macroscopic observation of teeth is usually the only technique used for analysis. Therefore, no attempts were made to determine whether tooth wear found was a result of dental attrition, abrasion or erosion. The results obtained are therefore inclusive of all dental wear processes. The direction and form of tooth wear was not examined on the study sample.

Results

The sample of permanent teeth included in this analysis is made up of 52 central incisors, 60 lateral incisors, 72 canines, 77 first premolars, 67 second premolars, 80 first molars, 58 second molars and 42 third molars, thus totaling 508. Deciduous teeth were also included in the analysis.

Most of the teeth are clustered between scores of one and two, with a smaller number of teeth showing severe dental wear. Severe dental wear tends to be most common on posterior teeth. However, in some individuals both anterior and posterior teeth were affected almost equally, for example, Taukome Burial 2 is characterised by advanced dental wear of all mandibular teeth (Figure 7.2). Enamel still surrounds dentine in some of the teeth but on the left first molar it has been eroded on the buccal surface.

Figure 7.2 Mandibular teeth of Taukome Burial 2 showing advanced wear



A summary of the degree of wear on various permanent teeth is shown in Table 7.4. The Table indicates that maxillary teeth were generally less worn than mandibular teeth. The scores of advanced tooth wear are more common on posterior teeth than on anterior teeth. For example, 16 teeth have been allocated a score of four. Of these teeth, there is one canine, three are first premolars, two are second premolars, six are first molars, three are second molars and one is a third molar. Thus 15 of the 16 teeth with advanced wear are posterior teeth.

Dental wear rates on both the study sample and K2/Mapungubwe are similar to that for hunter-gatherers, but both populations were agriculturalists (Denbow 1982; Steyn 1994). Two possible explanations for this is that their food may have had high abrasives content or they may have regularly used their teeth as tools. Using anterior teeth as tools commonly results in them being worn rounded (Morris 1984). Thus the absence of rounded incisors at K2/ Mapungubwe suggests that this was not a common practice. A few individuals with rounded maxillary incisors were identified among the Toutswe skeletons e.g. Bosutswe Burial 12.

On the Kalahari San, dental attrition was found to be more pronounced on anterior teeth than on posterior teeth in both the maxilla and the mandible. The second and third molars of the San people were the least affected (Van Reenen 1964c; 1982). This had resulted in a generally reduced crown height of these teeth. Observations of the modern San people have revealed that they use their anterior teeth as tools and therefore this could be a reason for reduced crown height on their incisors (Van Reenen 1964c; 1982).

7.4 Odontometric Characteristics

Introduction

Divergence or 'distance' between individuals or populations was first calculated using the 'coefficient of racial likeness' (CRL) developed by Pearson in the 1920s (Penrose 1954; De Villiers 1968b). Divergence between individuals was estimated through a combination of numerous measurements of different characteristics. CRL was subsequently replaced by size and shape distances following the realization that it did not account for intercorrelation between anthropological characteristics.

Table 7.4 Summary of scores of dental wear on permanent teeth.

				Maxillary teeth				
S	**I1 (n)**	**I2 (n)**	**C (n)**	**P1 (n)**	**P2 (n)**	**M1 (n)**	**M2 (n)**	**M3 (n)**
0	1	6	9	13	9	11	12	8
1		4	6	8	7	8	11	8
2	12	8	13	8	9	15	11	6
3	4	2	5	4	6	5		
4		1		3	2	4		
5	2	5	2	2				
6	2	2						
7								
				Mandibular teeth				
0	**I1 (n)**	**I2 (n)**	**C (n)**	**P1 (n)**	**P2 (n)**	**M1 (n)**	**M2 (n)**	**M3 (n)**
1	7	7	9	12	9	13	8	6
2		3	5	6	7	6	8	6
3	17	16	17	14	8	6	9	5
4	7	6	6	6	10	10	7	2
5						2	3	1
6								
7				1				

S- score

(n)- number of teeth

By the mid 1950s Penrose had developed a statistical method for calculating size and shape distance between similar variables across two or more sets of data (Penrose 1954, De Villiers 1968b). Shape or morphological differences between individuals or groups enable anthropologists to assign such individuals or groups into particular population groups (Penrose 1954). It compares sets of data obtained from three or more individuals or groups and indicates the closest similarity between any two sets from the numerous sets of data included in the study. For example, a comparison between groups A, B, C and D would produce shape distances between A and B, A and C, A and D, B and C, B and D and between C and D. The smallest distance between any of these combinations would mean that the two individuals/groups are closest to each other (Penrose 1954; De Villiers 1968b). It has been established that size difference does not play a significant role in determining population affinities of individuals unless such size differences are of great magnitude. Therefore distances using this method are usually expressed as shape distances.

Both metric and non-metric (i.e. size and morphology) features of a tooth have been found to be good indicators of racial affinity since they are under strong influence of genetic rather than environmental factors (Portin and Alvesalo 1974). Therefore, studies of dental characteristics of an individual or populations are an important and reliable tool of estimating the population affinity of an individual or population under investigation (Jacobson 1982). Studies of this nature have been done on both archaeological and modern populations in southern Africa (Steyn and Henneberg 1997b). Data derived from modern populations (e.g., Van Reenen 1982; Jacobson 1982) was used to establish possible relationships between archaeological populations and present day communities (Steyn and Henneberg 1997b). A study by Steyn and Henneberg (1997b) has established matrices of Penrose shape distances for maxillary and mandibular teeth based on various skeletal collections. The current study is therefore adding a new set of data to an already existing body of information.

The Penrose size and shape distances can be used to determine population affinity on the basis of both dental and cranial measurements. The cranial data set of the sample is too small to warrant further analysis cranial measurements can be seen in Appendix 1

Methods

The measurements used to calculate shape distance was buccolingual and mesiodistal diameters of permanent teeth. Buccolingual distance was taken as the maximum interproximal distance for any tooth and mesiodistal diameter was measured perpendicular to the buccolingual distance (Van Reenen 1982; Jacobson 1982; Hillson 1986; 1996). Males and females were pooled because of small sample size. Table 7.5 summaries the mean buccolingual and mean mesiodistal diameters and standard deviations of maxillary and mandibular left permanent teeth. There are 144 maxillary permanent teeth and 157 mandibular permanent teeth. The mean values of the buccolingual and mesiodistal diameters of permanent teeth measured were calculated. Standard deviations were also computed for the measurements (Table 7.5). The data included was derived from permanent teeth of the left side. Teeth of the right side were only used when their left counterparts were not measurable. Teeth that did not allow for measurement of one of the characteristics were excluded. Those teeth that were loose from the alveoli and unidentifiable were excluded. Crown height was not measured because its dimensions are influenced to a large degree by occlusal wear, which varies from individual to individual. Teeth showing advanced dental wear were excluded

The shape distance is performed in four steps (Penrose 1954; De Villiers 1968b). The first step is to establish common standard deviations for all samples included in the matrix. In the second step, for every two populations being compared, the differences between standardised means for each variable were summed (d^2) and divided by the total number of variables (n) to come up with the mean square distance. Thus mean square distance (CH) was calculated using the formula below.

$$C^2_H = (\Sigma\, d^2)/n$$

The third step is to establish size distance (CQ), which is the sum, squared d (Σd^2) values divided by the total number of variables. Thus:

$$C^2_Q = [\, (\Sigma\, d^2)\, /n]^2$$

In the final step, shape distance is calculated by subtracting the size distance from the mean square distance i.e.

$$C^2_P = C^2_H - C^2_Q$$

The calculations were tabulated on an excel worksheet. For further clarification regarding these calculations, the reader is referred to Penrose (1954) and De Villiers (1968b).

The matrixes of Penrose shape distances were tabulated for maxillary (Table 7.6a) and mandibular teeth (Table 7.6b). The data was pooled from males and females. Data from five sample populations was used for comparison and the samples included are Mapungubwe, K2, South African blacks, Kalahari San and the Australian aborigines (Van Reenen 1982, Jacobson 1982, Kieser 1990; Steyn and Henneberg 1997b). The K2 and Mapungubwe data were not pooled in this analysis. The term 'Negro' used in previous studies has been replaced by 'black' in the current study but the original data from the sample population remains unchanged. The samples included for comparison were selected for various reasons. Mapungubwe and K2 skeletons have been used continuously in the current study as a reference population. South African blacks and the Kalahari San are modern populations who have been studied before (Jacobson 1982, Van Reenen 1982) and therefore their odontometric data was easily accessible. The Australian aborigines (Kieser 1990) were selected as an outlier to show contrast with the southern African populations. All these samples have been compared with each other before and with the Australian aborigines (Kieser 1990; Steyn and Henneberg 1997b).

Results

Results of the matrix of Penrose shape distances of the maxillary teeth indicate that Toutswe people had a closer affinity with the South African blacks than with other groups. In the case of both the maxillary and mandibular teeth, the shortest distance between Toutswe any other group is with the South African blacks followed by the Australian aborigines and K2. It is not surprising that the South African blacks demonstrate close associations with the Toutswe people given that the former are generally believed to be descendants of southern African Iron Age communities, which include the Toutswe people. Given that the Australian aborigines come from a completely different geographic area, they were expected to be one the furthest from Toutswe in terms of shape distance. The reason for this apparent closeness between Toutswe and Australian aborigines is not clear.

The furthest distance is between Toutswe and Mapungubwe and the San people. This is not surprising given that the San are known to have smaller teeth than other South African populations (Van Reenen 1964a; 1982), and they are expected to be distant from the Toutswe people. The Mapungubwe people have the largest teeth known from southern African archaeological populations (Steyn and Henneberg 1997b). It can be concluded that the Toutswe people form part of the broader ancestral southern African black population group.

7.5 Dental modification and miscellaneous characteristics

Introduction

Dental mutilation is a fairly common practice on southern African prehistoric and modern populations (Van Reenen 1978a; 1978b; 1977; Steyn 1994; Morris 1998). In fact some of the earliest inhabitants of southern Africa from are known to have practiced some forms of dental mutilations. However the practice seems to have lost popularity with time (Morris 1998). Most dental mutilations appear to have been associated with personal beautification or initiation at the onset of puberty (Van Reenen 1977; 1978a) and in recent times they may be symbols of youth gangs (Morris 1998). Studies have shown that the Herero people in Namibia and North West Botswana and the Kalahari hunter-gatherers are some of the few modern communities practicing dental modification in Southern Africa.

Different kinds of dental modifications have been reported from various parts of the world (Buikstra and Ubelaker 1994). The forms range from extraction of anterior teeth or chipping crowns to a blunt point (Van Reenen 1977; 1978b; Morris 1998) to making incisions without extraction (Van Reenen 1977; 1978a; 1978b; Buikstra and Ubelaker 1994; Morris 1998). Incisions may be made on occlusal surfaces or on labial surfaces. While in some populations dental mutilations are restricted to maxillary teeth, in some they may include mandibular teeth. The v-shaped incision between maxillary central incisors is a commonly found form dental mutilation in southern Africa (Van

Reenen 1977; 1978a; 1978b; Steyn 1994) and has been reported in both archaeological and modern populations. Swallowtail form of dental mutilation has been reported from teeth found at Broederstroom, an Early Iron Age site dated circa 500 AD in South Africa (Van Reenen 1977).

Table 7.5 Mean and standard deviations of permanent teeth

	Tooth	n	Mean Buccolingual	SD	Mean Mesiodistal	SD
Maxillary	M3	11	10.80	1.63	8.95	1.36
	M2	19	11.30	1.53	9.86	0.95
	M1	26	11.29	0.77	10.32	1.11
	PM2	18	9.63	0.70	6.68	0.88
	PM1	20	9.65	0.75	7.08	0.93
	C	20	8.74	0.87	7.65	0.83
	I2	17	6.99	1.43	6.71	1.24
	I1	13	7.33	0.68	8.67	1.52
	Total	**144**				
Mandibular	M3	10	10.16	0.83	10.80	1.05
	M2	20	10.51	0.59	10.79	0.76
	M1	27	10.85	0.53	11.31	0.74
	PM2	19	8.45	0.76	7.30	0.56
	PM1	21	8.24	0.60	7.25	0.65
	C	21	10.54	14.63	7.08	0.47
	I2	19	6.31	0.30	5.82	0.65
	I1	20	5.85	0.29	4.97	0.78
	Total	**157**				

Table 7.6a Matrix of Penrose shape distances (maxilla)

	Toutswe	Mapungubwe	K2	SA black	San	Australian aborigine
Toutswe	-	0.265	0.159	0.077	0.769	0.127
Mapungubwe	-	-	0.423	0.453	0.750	0.398
K2	-	-	-	0.189	0.196	0.285
SA black	-	-	-	-	0.190	0.117
San	-	-	-	-	-	0.373
Australian aborigine	-	-	-	-	-	-

Table7.6b Matrix of Penrose shape distances (mandible)

	Toutswe	Mapungubwe	K2	SA black	San	Australian aborigine
Toutswe	-	0.459	0.275	0.18	0.447	0.174
Mapungubwe	-	-	0.369	0.382	0.521	0.695
K2	-	-	-	0.216	0.783	0.590
SA black	-	-	-	-	0.708	0.248
San	-	-	-	-	-	0.586
Australian aborigine	-	-	-	-	-	-

Methods

All anterior permanent teeth with complete crowns were analysed for dental modifications of any kind. Miscellaneous dental characteristics such as peg and shovel shaped teeth were noted where identified.

Results

One individual appears to have performed dental modification. The individual found was a child of 10 to 12 years old (Toutswemogala Burial 16). An inverted v-shape incision produced between maxillary central (Figure 7.3) does not go all the way to the alveolar, as is the case in some Herero communities (Van Reenen 1978a; 1978b). This modification is obtained by filling corners of mesial ends of central maxillary incisors. The skull of this individual was found buried in isolation (Lepionka 1971; 1978; De Villiers 1976) possibly for ritual purposes. The form of dental modification identified on this individual is common among the San hunter-gatherers of North West Botswana and adjacent parts of Namibia (Van Reenen 1978a; 1978b) as well as on the K2/Mapungubwe peoples (Steyn 1994). The same individual had alveolar prognathism (Figure 7.4) that had resulted in malocclusion of anterior teeth.

Other morphological characteristics identified include a bifid rooted deciduous left mandibular canine of Toutswemogala Burial 9, a child of approximately six to eight years old (De Villiers 1976). This is normal variation of the canine (Brothwell 1981; Van Beek 1983). Unfortunately the maxillary dentition of this individual is missing and the right canine is in situ and no x-rays were taken on this tooth and therefore its root was not observable. Peg-shaped incisors were noted on two individuals, Toutswemogala Burial 17 and Bosutswe Burial 12. In both cases the incisors are lateral and permanent. In the case of Toutswemogala Burial 17 both lateral incisors show this feature while on Bosutswe Burial 12 only the right incisor has this shape. Bosutswe Burial 13 demonstrates shovel-shaped maxillary central incisors. Kgaswe B-55 Burial 15 has shovel shaped maxillary central incisors. These characteristic features occur in small number and not much can be inferred from them.

Figure 7.3 V-shape dental modification of maxillary central incisors on Toutswemogala Burial 16

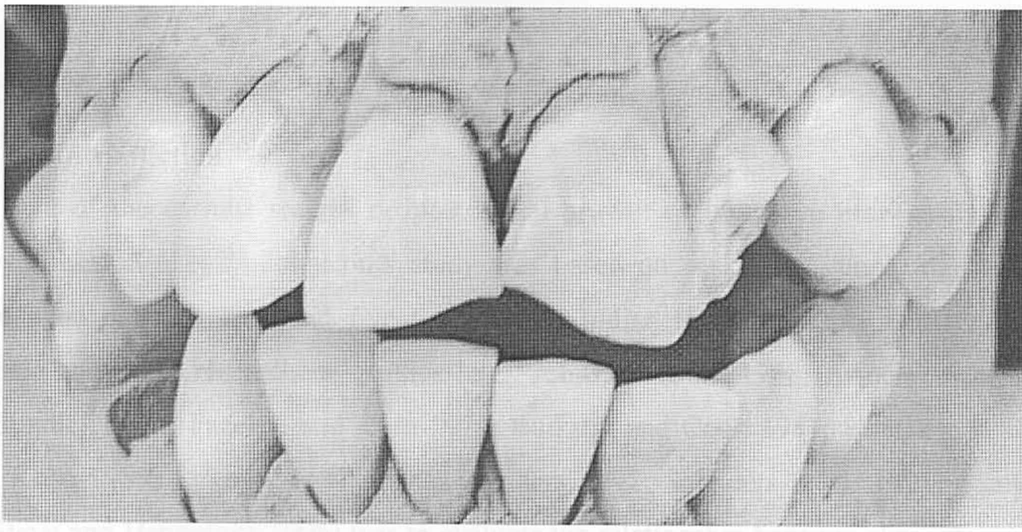


Figure 7.4 Lateral view of Toutswemogala Burial 16 skull showing prognathism of anterior teeth.