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The interpretation of variation in skull porosities by burial position in the Dynasty I royal cemetery complex in Abydos, Upper Egypt

One of the goals of palaeopathology (and human biology in general) is to describe and explain the patterns of disease in relationship to social position. There is an easily envisioned and documented relationship between social status and health, if the former determines access to nutrients, the overall environmental quality, and the ability to provide and receive medical care (Crooks 1995). It has long been understood that other factors such as occupation, age and sex may have health implications.

This paper presents the results of a comparative palaeopathology study of remains from subsidiary burials associated with the Dynasty I Egyptian kings Djer and Djet (Uadji), the second and third, or third and fourth kings of the dynasty, depending on who is regarded as the first ruler: Narmer or Aha (Wilkinson 1999). Porous defects, broadly called porotic hyperostosis, were studied in the crania of groups buried in the two separate areas of the royal cemetery complex in Abydos, Upper Egypt. The primary goal was to compare and contrast the group frequencies of affected individuals, and explore the possible social meanings of the observed pattern. The study is one of adults buried in a royal context and not of demographically complete groups.

Dynasty I was the first half of the Early Dynastic or Archaic period of ancient Egyptian history (Spencer 1993; Wilkinson 1999). The Early Dynastic is the bridge between the later predynastic, when kings first emerge in Egypt, and the Old Kingdom, well known because of the pyramids. This epoch is significant because during this time state power and institutions were consolidated. Annals were initiated during the First Dynasty, by its likely first king Aha. The political center of the country was moved to Memphis in the north, by a dynasty from the

south, where the clear precursor of dynastic culture developed. The Early Dynastic can be seen as a distinct phase in Egyptian history, and included the custom of burying retainers with the kings. This practice was apparently stopped for unknown reasons at the end of Dynasty I, and its origins are just as mysterious. The custom may reflect beliefs about the maintenance of courtly order in the afterlife, and known primarily from Dynasty I. King Aha, the likely first king of Dynasty I, also had subsidiary burials possibly including his wife, along with a cohort of young individuals estimated to be between twenty and twenty-five years of age, suggesting that the latter did not perish of natural causes (see Dreyer et al. 1990; Dreyer 1993, Spencer 1993, Wilkinson 1999). It is not known if these persons volunteered to serve the king in the afterlife, or if they were coerced. These retainers, a sample of who are studied here, were part of a unique short-lived tradition in the long history of ancient Egypt. One of this effort's goals is to learn something about the possible social origins of these people via an exploration of one aspect of their biology.

The Cemetery Complex

The royal cemetery complex at Abydos holds all of the graves of the rulers of Dynasty I (Kemp 1966, 1967), whose physical remains unfortunately no longer exist. Predynastic kings and elites were also interred at Abydos, a holy place to the ancient Egyptians, and a possible locale of origin for these Dynasty I kings, who were buried in perhaps what was regarded as an ancestral home, instead of in northern Egypt (Spencer 1993; Wilkinson 1999). The main part of the cemetery, called Umm El Qaab, contains the actual tombs of the rulers and associated burials (Petrie 1900). These subsidiary graves are those of court functionaries, as indicated by stelae, who are generally regarded as having comprised the rulers' personal entourage (see Kemp 1966; Trigger 1983; Spencer 1993). However, the idea that they were simply servants or slaves has been contested in the past (Thomson & MacIver 1905; Petrie 1925). Approximately one mile away are another set of burials arranged essentially in squares (Petrie 1925) which outline once existing structures called „funerary palaces" or funerary enclosures (Kemp 1967; O'Connor 1989). These graves can be identified with the reigns of particular rulers by associated goods (Petrie 1925). Their occupants were apparently a mixture of artisans and lower court officials such as a „seal bearer." In either case in life the individuals in both areas would have been of lower rank, just above ordinary people. Both sets of individuals – the royal tomb and funerary enclosure groups – are believed to have been interred at or near the time of the rulers' deaths, but the actual number for which this is true is unknown (Hoffman 1979), except perhaps in the case of Aha.

Vault Porosities

„Porotic hyperostosis" is generally used to describe porosities in the outer table of the cranial vault associated with a widened diploic space, and has varying degrees of severity (Hillson 1978; Ortner & Putschar 1981; Goodman et al. 1984; Larsen 1997). The classical heuristic depictions of porotic hyperostosis show grass large bilateral vault porosities in notably thickened parietal bones, and usually in children, but this is only the most severe manifestation. Porous lesions in the orbital roof(s) are usually called cribra orbitalia. These porosities are not believed to be a disease in themselves but rather a marker indicating that a physiological insult has occurred.

The classic defects, whether in vaults or orbits, are stated to be caused by a compensatory expansion of the marrow in the flat skull bones (Larsen 1997), which is most easily explained as a response to the decreased longevity of red blood cells and altered iron metabolism, as found for example in thalassemia major and sickle cell anaemia. In most archaeological samples the cause of the lesions is usually hypothesized to be due to dietary iron deficiency (Sanford et al. 1983; Stuart-MacAdam 1985, 1992; Larsen 1997). However, experimental data make it possible to be more certain about the causes of these lesions, when the aetiology is not thought to be hemolytic anaemias. Rats chronically bled show a much greater marrow response than those given an iron-deficient diet (Burkard et al. 2001). By extrapolation this means that chronic blood loss associated with parasitic diseases such as schistosomiasis and hookworm are likely to cause the marrow response that causes vault porosities. Theoretically iron loss from diarrhea, also found associated with various infectious diseases could trigger a significant marrow response. Reflex mechanisms that lower serum iron in some bacterial infections might sometimes be a factor also (see Kent & Weinburg 1989; Stuart-MacAdam 1992).

The aetiologies of anaemia have to be considered in the contexts of crowding, poor general nutrition, weaning stress and overall disease burden, including chronic infections (Kent 1986; Palkovich 1987), and the handling of sanitation (see e.g. Dixon 1972). It would be short-sighted to simply reduce the issue to one of an abstract iron deficiency anaemia, except in the most severe cases of blood loss. The quality and disease ecology of the total environment, and their total impact on physiology have to be considered.

The anaemias associated with chronic and inflammatory disease (see Abshire 1996) could also be indirect aetiologies or contributors, as could malnutrition, which lowers insulin growth factor -1 (IGF-1), a known erythropoetic (blood stimulating) factor (Erickson & Quesenberry 1992; Cohick & Clemmons 1993; Adamo 1995). Using the phenomenon of catch-up growth as a model, it is possible that as a part of recovery from chronic disease and malnutrition that an

accelerated marrow response would occur with resulting porosities, but this idea remains to be explored. Vitamin D deficiency can also be associated with porous vault lesions and same diploic widening (Ortner & Putschar 1981, but see Larsen 1997 for a different opinion on diploic expansion). Genetic anaemias, as stated, may also cause defects, but the recovery of a notable number of affected adult individuals from an ancient adult sample would be expected to be relatively rare due to low incidence, disease related early mortality, and the general pre-adult mortality associated with early societies. Sickle cell anaemia has been diagnosed by molecular means in predynastic remains that exhibited porotic hyperostosis (Marin et al.1999).

Other defects and causes have to be considered in the evaluation of vault porosities. Localized lesions confined to the periosteum may indicate primary periostitis, and are usually related to trauma or proximal scalp infections. If symmetrically widespread and restricted to the periosteum lesions may indicate vitamin C deficiency or secondary periostitis, the latter being understood to reflect a general inflammatory response to a non-local process. Poor vitamin C intake is less well documented as a cause (Ortner & Putshcar 1981). In the Nile Valley secondary periostitis would likely be a part of the response to parasitic infection, given the endemicity of schistosomiasis and hookworm (Stephenson & Holland 1987; Tanaka 1989), even if the infection is not severe enough to provoke grossly detectable diploic expansion.

Vault porosities thought to be related to iron deficiency are hypothesized to initially manifest only in childhood and do not occur in individuals who first become anaemic as adults, based on deductions from cross sectional research (Stuart-MacAdam 1985). Unfortunately there are no confirming longitudinal or experimental studies, hence this remains a working hypothesis. (Periostitis could occur at any time.) It is known that skeletal lesions do not occur or are not severe in all anaemic individuals, even children with sickle cell disease. Hence from a clinical perspective it would be advantageous to incorporate the idea of a continuum of bony lesions, and record a range of porosity manifestations so as to capture as many as possible of those affected.

The assessment of adult crania is made challenging by remodelling, but this does not usually obscure that a given individual was affected; it could, however, hinder understanding the severity of the initial lesions. It is assumed that quantitative and qualitative variations in adult skull cohorts reflect the relative differences that would have been found in childhood-assuming the lesions related to anaemia to only occur at this time; the simplifying assumption is that there are no great differences in remodelling rates between surviving groups. There is a caveat. Inter-group variability in adult frequency (percentage of skulls with lesions) could also be affected by group differences in pre-adult mortality,

assuming that the samples under consideration are from distinct and „real" populations (or strata); this demographic information is not known for this material, which in part likely is of people from northern Egypt (see Keita 1992). The royal context of the material used here has likely implications for interpretation.

Lesions in early Egypt would most have likely been related to anaemia, either from parasitic, genetic and/or dietary related causes in the context of a challenging socio-ecological environment with a high biological challenge. It is likely that blood logs from schistosomiasis and hookworm are primarily responsible, or have the major role for these lesions. Secondary periostitis would also be expected. Vitamin D deficiency can reasonably be excluded as a frequent cause because of the high solar radiation. Given the concern here for examining the pattern of pathology in relationship to social position, a childhood aetiology of the lesions – if this assumption is correct – would be advantageous, because it may reflect aspects of social origins. Early childhood lifestyle and life-history are more likely to reflect aspects of social life such as rank or status because of the vulnerability of children (Nestel 1990), and ties to their parents' social position. Social status in adulthood may not be the same as that held in early life, even in an ancient monarchal society. This study offers the opportunity to examine lesions believed to reflect a health insult of childhood, in two groups of adults with broadly different roles at the royal court.

Material

The material studied consists of adult crania from the burials around the tomb of King Djer primarily, and from the lower cemeteries (funerary enclosure sites) of Kings Djer and Djet as far as can be ascertained. The available remains represent a fraction of court functionaries, the „populations" actually interred (see Petrie 1925). Djer's tomb was flanked by 318 subsidiary graves, and his funerary enclosure by 269. King Djet's retainer burials numbered 174 and 161, respectively. Sex was determined by standard anatomical criteria, and considering the names of individuals when known, as well as the range of variation in Egyptian skeletal populations. It is suggested that the royal tomb sample has 27 males and 17 females, and the enclosure tombs 38 males and 10 females. ANOVA showed no differences by sex and the subgroups. In principle sex subsamples can be combined to obtain a group impression, if this is desired, because the lesions do not connote diseases that are biologically sex-linked. The total sample sizes were 44 and 48 for the two locales respectively. The royal tomb material is stored in the British Museum of Natural History. Cambridge University houses the funerary enclosure/palace sample.

Due to various kinds of damage not all structures of interest were present or complete in each cranium. The sample sizes by structure are below:

	Royal Tomb	Funerary Enclosure/Palace
Orbits (roofs)	37	45
Vaults (all)	44	48
Vaults (most complete)	37	42

The second grouping of vaults refers to those having all three bones complete or nearly so.

Methods

The standard method of approach is based on macroscopic observation with the naked eye. For this study porosities were assessed in two ways. Vault, but not orbital, porosities were graded from 0-6 following Hillson (1978). The grade is used as a variable called the vault porosity score (VPS) and noted as below:

0 -   no porosities
1 -   scattered fine porosities
2 -   larger porosities
3 -   some linked porosities
4 -   "canal like" linked porosities
5 -   small trabecular outgrowths from outer table
6 -   marked trabecular structure on the outer table

This approach acknowledges a continuum of porous lesions. All defects were noted. It is important to reiterate that the goal was to capture all individuals who bad been likely affected physiologically, in order to get a more accurate picture of the frequency of affected individuals. A more clinical perspective is justified given that not all individuals with anaemia have skeletal manifestations.

Lesions were mapped for each vault onto a schematic that included the coronal, sagittal and bregma sutures. VPS was recorded for the most anatomically severe lesion wherever found, which was usually the parietals. The number of kinds of superior vault bones affected was recorded as the extent score (ES), range 0-3. (Parietal involvement was only counted once.) Two dichotomous variables were devised. The first designates vaults with any lesion porosity scores of one or more and is called VPP1. The second enumerates vaults with lesions of porosity scores of two and greater (VPP2), and is of more interest in this study, because previous experience has shown that this variable was more often associated with same parietal thickening. VPP2 serves as a kind of screen, facilitating the recording of lesions perhaps more likely related to lesions beyond periostitis. Cribra orbitalia was scored as present or absent.

Parametric ANOVA, Mann-Whitney and contingency table analyses were carried out. The five percent probability level was chosen for significance.

Table 1. Dichotomous variables, comparisons

Series	N	Frequencies (%)		
		VPPI	VPP2	Cribra
Royal Tomb	(44,37)	77.3	47.7	35.1
Funerary Enclosure	(48,45)	45.8	14.6	11.1
χ^2		9.53	11.91	6.84
ρ		0.002	< 0.001	0.008

Table 2. Means and Standard Deviations, Comparisons

	VPS			ES		
	N	Mean	SD	N	Mean	SD
Royal Tomb	44	1.74	1.18	37	1.97	0.93
Funerary Enclosure	48	0.74	0.76	42	0.98	0.92
Comparisons						
ANOVA ρ	< 0.001	(F = 23.64)		< 0.001	(F = 22.82)	
Mann Whitney ρ	< 0.0001	(Z = -3.85)		< 0.0001	(Z = -4.20)	

Results

A range of lesion quality was observed. Noticeable although not necessarily severe parietal thickening was usually observed with the higher grade lesions; thus the second variable (VPP2) tends to restrict the count to those vaults having lesions closer to „porotic hyperostosis" as originally described (see Angel 1964, Ortner & Putschar 1981), although mild. Skulls with extreme classic lesions were not found, an observation made about other Egyptian material by Hillson (personal discussion). Same crania had what might be described as pitting not porosities, perhaps representing remodeling or other tissue activity. The royal tomb and funerary palace samples have lesion frequencies above ten percent in all dichotomous variable categories (Table 1). Lesions with a porosity score of one were not generally associated with visible thickening and could be due to periostitis. The level of porosity-defined lesions is noteworthy in the two samples. The frequency of individuals having any degree or kind of vault lesion is greater than forty-five percent.

Contingency table analyses indicate significant inter-group frequency differences (Table 1). The royal tomb group is observed to have three times more affected individuals than the funerary palace sample for cribra and higher grade vault lesions (VPP2). Those from around the royal tombs have one and a half times the observed lesions (VPP1), found in the funerary palace folk. The percentage of crania having a vault porosity score of one, obtained by subtracting VPP2 from VPP1, is nearly the same for both groups, approximately thirty percent. This suggests a general background of biological challenge resulting in lesions largely restricted to the periosteum.

The average porosity score and extent of porosity lesions per individual for the royal tomb vaults, is twice that of the funerary palaces (Table 2). Although the standard deviations indicate high within sample variability, the central tendency differences are statistically significant.

The results are consistent across measures in suggesting that the individuals recovered from around the funerary palaces sustained less childhood physiological challenge productive of skull porosities. Fewer individuals were affected, and those who were had less anatomically severe lesions.

Discussion

Although both series evince noteworthy levels of pathology, the royal tomb sample has more severe lesions and a higher frequency of affected individuals with a vault porosity score of two or more. Strictly speaking it can only be said that a group difference in vault porosity frequency and severity exists in the recovered material. Therefore any interpretive scenarios are admittedly speculative.

As a starting point, and tentatively accepting Stuart-MacAdam's (1985) interpretation, it is worth noting that there is a difference in two adult groups for a lesion hypothesized to occur in childhood. In a hypothetical society with high social mobility, one could reasonably expect no difference between adult groups for a childhood lesion. In one without such equality such differences might be expected to „cluster" in adulthood groups, assuming that the social position of children and adults was somehow connected. If porosities associated with diploic expansion do represent a childhood lesion then they can be seen as an osteo-biographical tool that allows the social „tracking" of individuals or groups in some selected circumstances.

Does the inter-group difference *itself* imply that those from the two sub-sites are true samples from distinct „populations" within which individuals are connected by a „principle" like class, caste or ethnicity? Or is it artifactual? This is a relevant theoretical and statistical question, with implications for other research in similar circumstances. Stated another way, do the recovered site

differentiated individuals represent true samples, either random or non-random, of actually existing entities („populations"), or are they non-statistical fragments of the general population? This must be kept in mind in any interpretive effort. There is no evidence that the crania preserved by the excavators represent a special selected sub-set of the burials.

The reason for the disparity between these „groups" may reflect institutionalized social structure. However, in order to knowledgably explore this possibility there would have to be a clear understanding of Early Dynastic social hierarchy and differentiation within strata. Unfortunately precise documentation for these is lacking. The emic status of either group is not known. There seem to be no later Egyptian references to internal social ranking in this early period, or to the custom of having current court functionaries buried at the time of the rulers (Baines, personal communication). The results of studies of later dynastic Egyptian society are consistent with there being four broad strata (Trigger 1983). By extrapolation the Early Dynastic individuals interred around the royal tombs and funerary palaces would have ranked below the ruler and royal family, nobles and high officials, and just above the „peasants." (The exceptions would be wives, if in fact they were interred, even in the case of Aha.) Grave goods and stelae have been interpreted as marking the royal tomb occupants as having primarily been the rulers' personal retinue, and as noted largely of servile status. The funerary enclosure group was composed apparently of minor officials and artisans as indicated by titles and the presence of fine copper tools (Petrie 1925). Some scholars, working in a presentist mode based on later periods, would interpret these individuals as a group as having higher status (Baines, personal communication). However the interpretation of status from funerary remains is always difficult (Ucko 1969).

Several biosocial models are consistent with the findings. If the funerary enclosure group consists of individuals from a strata or „population" with higher ascribed status, then the results fit current normative expectations, namely that better health tracks with higher social status, all other things being equal. These individuals in childhood would have theoretically been at less risk for disease challenge, especially for chronic conditions related to nutrition. In this case the usual interpretation of the royal tomb group as simply servants would be accepted. This is attractive but builds in the assumption that court „servants", companions of the king, were recruited from the „poor." A 'class' explanation works no matter when the lesions appear in life, or their aetiology(ies), and only requires that the defects represent evidence of a pathological condition. For example if the lesions were acquired in adult life, then it would suggest that those buried around the king did work which placed them at greater risk.

If the royal tomb folk were in origin from a group of ascribed higher status then the results would require a less straightforward explanation. One of these would be that the higher status permitted the parents to invest more in sick children; thus more of them survived to adulthood, if the diseases in question were life threatening. A higher lesion frequency in an adult cohort in this instance would indicate a higher survival of challenged individuals who are missing from the other group, in which „better health" is actually an illusion. This is an example in one sense of what has been called the osteological paradox (Wood et al. 1992). The adult status of the royal tomb occupants in life may deserve further enquiry. It may be important to consider the burial adjacent to the rulers as being significant, irrespective of titles. The concept of status may need rethinking for Early Dynastic Egypt. If the lesions occurred in adulthood, some special exposures due to custom or ritual might have to be invoked to explain why a group with higher status had more pathology, unless the group was endogamous and the lesions are related to genetic conditions. The osteological and other paradoxes make it difficult to know if the pathology can be used to construct an interpretation, since the ontology of any models may be inappropriate.

Another interpretation is plausible and employs the concepts of phyles described from ancient Egypt (Roth 1991), and hereditary occupational castes linked to kings or elites, the latter even known from more recent societies (see Levtzion 1973 and Tamari 1991). The evidence suggests that phyles were clan-like hereditary based work associations associated with kingship (but not exclusively), and may have developed from predynastic totemic clans. Symbolically in the Early Dynastic world it is conceivable that phyles or phyle-associated groups would have been expected to assist the king in the afterlife. The royal tomb and funerary enclosure groups may be of the same social rank, but horizontally differentiated by the professions of the households into which they were born or recruited as young children, thereby participating in the work associated with these domiciles or homesteads.

Young artisans (and other non-farmers) would have been less exposed to parasitic infections and their nutritional sequellae than agriculturalists or share fishermen exposed to Nile alluvium. There is positive evidence for childhood occupation differences; the footprints of children approximately six years of age have been preserved in plaster at some elite Early Dynastic building sites (Baines, personal communication), and children are seen in paintings of farming activities. An occupational model would explain the group difference if the royal tomb folk were drawn from farmers, and the funerary enclosure sample connoted artisans or at least non-farmers, both perhaps connected to the kingship, assuming that the lesions are of childhood origin. Differences would stem from occupation irrespective of class status. It is not unreasonable to postulate that the

personal retinue of the king would have been a part of a household unit that also farmed, and that the adults in the household as children helped in food production, thus sustaining a higher exposure to parasites, than the children of non-farmers. Although there is no described direct evidence that the samples in this study were from phyles, the individuals represented did perform broadly different kinds of work. Although it is known that phyles in the Old Kingdom rotated different kinds of work, they may have initially more confined to one occupation.

Another possibility is that the royal tomb people comprised a hereditary companion servant caste, fed from infancy a ritually prescribed, but nutritionally deficient diet, and perhaps secluded from the sun, in a kind of purdah. However, there is no known documentary evidence for such a practice, or reference to it in later texts (Baines and Roth, personal communication). Also there are no long bones to assess for rickets.

The occupational model receives additional but indirect support from an analysis of linear hypoplasias on the first and second molars. One would expect markers of severe physiological stress to track with each other. However, there is no statistical difference between the royal tomb and funerary enclosure samples for this lesion at any level. The frequency of individuals having first molar defects was 35.0 and 36.4 percent respectively [n = 22 (RT) and 40 (FE); Chi square = 0.012; p = 0.914); and for the second molar 42.1 and 41.7 percent [n = 24 (Re) and 38 (FE); Chi square = 0.001; p = 0.973]. The average number of lesions for each tooth in the two groups was also statistically insignificant (p>0.05). These findings would seem to show that the group contrast in porosity lesion frequencies does not reflect a difference in overall (general) insult to physiology. Otherwise it could reasonably be expected that the royal tomb sample would have had more linear hypoplasias; in fact if true this would lend somewhat more support to an explanation of a status difference in origins, since a general and specific indicator of childhood stress would both have high values. Instead a difference is only seen for the variable that can most easily be associated with a particular lifestyle/ecology and disease risk.

There is some other supportive evidence as well. A Dynasty I Thebaid sample from a non-royal context was evaluated for the prevalence of vault porosities (n=36). The percentage of VPP1 lesions was 63.9%, and 47.2% for VPP2. The prevalence of cribra was 37.1%. These percentages are no statistically different from those in the royal tomb sample (p> .05). These individuals were from a non-royal context, and likely peasant farmers. In any case they were non-royal. The fact that the porosity pattern of the non-royal group and one from a royal context are indistinguishable could be interpreted as suggesting similar kinds of childhood exposure. As it has been argued parasitic diseases would have

been greatest in those most exposed to the Nile and its alluvium, and engaged in work requiring such exposure.

The recovery of more data from predynastic and dynastic contexts may provide the information with which to make better social inferences about these findings. No definitive conclusions are possible at this time. However, based on a synthesis of the available evidence some variant of the model incorporating horizontal occupational differentiation, with or without the concept of hereditary caste, would seem to have more power in explaining the differences than a simple hierarchical class model, using the hypothesis that the lesions are of childhood origin.

Acknowledgments

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