Palaeopathology in Egypt and Nubia

A century in review

Edited by

Ryan Metcalfe, Jenefer Cockitt and Rosalie David

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Occlusal macrowear, antemortem tooth loss, and temporomandibular joint arthritis at Predynastic Naqada

Nancy C. Lovell

Department of Anthropology, University of Alberta, Edmonton, Canada

Abstract

This paper is based on the results of an examination of crania and mandibles from three cemeteries at Predynastic Naqada, which were excavated by Petrie in 1895. These remains are curated as part of the Duckworth Collection at the University of Cambridge. Patterns of occlusal macrowear, antemortem tooth loss, and lesions of the temporomandibular joint (TMJ) are described, and are discussed in the contexts of diet and the biomechanics of mastication. The incomplete nature of most of the dentitions restricted the assessment of the pathological conditions, but no statistically significant differences were observed in the prevalence of TMJ arthritis between males and females, nor between elite and non-elite cemetery samples. Furthermore, antemortem tooth loss and occlusal wear were not associated with TMJ lesions.

Introduction

A workshop reviewing a century of palaeopathological research in Egypt and Nubia would not be complete without acknowledging the value of the skeletal collections acquired through the fieldwork undertaken by Sir William Mathew Flinders Petrie (1853-1942). Although it's true that Petrie was not concerned with the analysis of human remains himself, he supplied his colleagues at the University of Cambridge with skeletal remains from his excavations to aid their research in craniomorphological variation. This served to establish a number of rare collections dating from the Predynastic to the later Pharaonic eras.

One of these collections stems from Petrie's excavations at Naqada, which he undertook in 1894-1895, assisted by J. E. Quibell (Petrie and Quibell, 1896). Petrie shipped to Cambridge a portion of the material he excavated at Naqada for study by members of Karl Pearson's Biometrics School (e.g., Warren, 1897; Fawcett and Lee, 1902), but the continued curation of the remains at the University of Cambridge has made possible more recent analyses of biological affinities, diet, and health (e.g., Keita, 1990; Bartell, 1994; Johnson and Lovell, 1994; Prowse and Lovell, 1996; Keita and Boyce, 2001; Greene, 2006; Miller, 2008). Indeed, curated skeletal remains have provided the source of data for many of the foundational works in Egyptian and Nubian palaeopathology (e.g., Brothwell, 1963), and reviewed most recently by Forshaw (2009).

In this paper I describe patterns of occlusal macrowear, antemortem tooth loss (AMTL), and lesions of the temporomandibular joint (TMJ) among the Predynastic Egyptians

from Naqada, and discuss these patterns in the contexts of diet and the biomechanics of mastication. Rather than cover all aspects of dental disease, I have restricted the scope of this paper so that the focus is on lesions of the TMJ and the dental conditions that may be implicated in the cause of those lesions.

Materials and methods

Petrie identified three cemeteries at Naqada and the pottery from these cemeteries provided him with some of the most important data upon which he based a new dating method and a chronology for Predynastic Egypt that bears the site's name. Skeletal remains from these cemeteries form part of the Duckworth Collection at the University of Cambridge, which now is housed at the Leverhulme Centre for Human Evolutionary Studies.

In this study, occlusal macrowear, AMTL, and lesions of the temporomandibular joint were recorded from remains representing a total of 123 adults (table 1) from the Great New Race Cemetery (usually known as Cemetery G, but also referred to as Cemetery N), Cemetery B (named after nearby Kom Bellal), and Cemetery T (named for its proximity to two tumuli). As can be seen in table 1, fewer than half of this total had complete skulls preserved. Furthermore, many of the preserved remains were incomplete in one form or another, either missing portions of the cranium or mandible due to damage unassociated with pathological conditions, or missing teeth that had been lost postmortem.

Cemetery	# Crania with associated mandibles	# Crania without mandibles	# Mandibles without crania	Total
G	29	19	16	64
B	9	17	10	36
T	5	11	7	23
Total	43	47	33	123

Table 1: The Naqada skeletal sample of adults available for examination of the teeth and alveolar bone and the components of the temporomandibular joint.

The postmortem loss of teeth can be attributed to problems of preservation (which is not uncommon when dealing with archaeological human remains in many parts of the world, particularly those remains that have not been protected in burial shafts or containers) and to loss of teeth during excavation and subsequent handling. In this sample, the single rooted incisors and canines were the teeth most commonly lost postmortem.

Estimation of the age at death for each individual followed standard bioarchaeological protocols. Unfortunately, age estimation methods for adults are highly imprecise, a situation that is made more difficult when only the crania are available for examination. In this study, ectocranial suture closure (following Meindl and Lovejoy, 1985) was the primary method used, with confirmatory evidence of age seriation obtained from the presence of endocranial impressions from arachnoid granulations (also known as

Pacchionian granulations). Individuals were then categorised as Young Adult (18 to 25 years), Middle Adult (25 to 40 years), or Older Adult (>40 years) in order to facilitate further analysis.

Sex was determined on the basis of secondary sex characteristics as exhibited in the morphology of the skull (Buikstra and Ubelaker, 1994) and the size of teeth, and the individuals were then characterised as Female or Male. The particulars of age and sex for each pathological condition vary according to the number of teeth and jaws that can be observed for analysis, and therefore are presented in tabular detail only for the conditions reported. Overall, however, the sample consisted of 72 males, 45 females and six individuals of indeterminate sex. Middle aged adults comprised over half of the sample when it was partitioned by age; this is probably due to a combination of the difficulty in obtaining precise age estimates for adult skeletons and the typical life expectancy in antiquity, and is not thought to cause problems for this analysis.

All identifiable teeth and fragments of the maxillae and mandibles were examined, inventoried, and their pathological lesions scored according to accepted disciplinary standards (Hillson, 1996). Teeth that were too fragmentary to identify were not included in the study, and those that were unobservable for particular features were omitted from certain analyses. Inter- and intra-observer error in the assessment of pathological lesions was assessed through re-scoring a portion of the sample and was found to be negligible.

A total of 1077 teeth were observable for pathological lesions (27% of the sample size that would be expected if all 123 individuals had possessed a full set of teeth). Occlusal macrowear was scored for all teeth following the illustration and accompanying descriptors developed by Smith (1984). Smith's eight stages of wear were then collapsed into four stages for further analysis: none (Stage 1), slight (Stages 2-4), moderate (Stages 5-6), and severe (Stages 7-8). This categorisation served to increase the subsample sizes for comparison, but, more importantly, took into account those cases where the observer felt that the wear was difficult to assign to only one stage and noted during recording that the wear was, for example, '5 to 6'.

A total of 1259 alveoli were observable for antemortem and postmortem loss (32% of the expected sample size). Antemortem tooth loss was recorded in cases of missing teeth when the alveolus exhibited a reactive process of bone resorption and/or deposition (i.e., healing); in cases of missing teeth where the alveolus was unremodelled the tooth was assumed to have been lost postmortem.

In addition, macroscopically observable lesions on the glenoid fossa (also known as the mandibular fossa) and the articular eminence (tubercle) of the temporal bone, and on the mandibular condyles, were scored according to the descriptors developed for changes to the form and surface of the condyle (Wedel, Carlsson and Sagne, 1978; Richards and Brown, 1981). Form change ranges from no observable change through slight and marked remodelling (including lipping at the anterior margin of the joint and clear presence of cortical cysts) to deforming change; surface change ranges from no change through uneven and irregular surface (the latter accompanied by perforation of the compact bone), to

destruction of the compact bone that is greater than 3 mm^2 in size. Radiographs were not employed in this study. Not all of the individuals presented complete temporomandibular joints (see table 1) but either mandibular condyles or glenoid fossae (and sometimes both) were observable in 116 individuals out of the total sample of 123 individuals.

The associations of AMTL and occlusal wear with disorders of the TMJ were examined statistically but required some modifications to categories of tooth loss and wear data: these factors are normally scored per tooth, whereas evidence of TMJ alteration is normally scored by individual. Thus, the average tooth loss score and the average occlusal macrowear score were calculated per individual, and the student's t-test was used to compare dental scores between individuals affected and unaffected by TMJ alterations.

Intra- and intercemetery analyses of cranial and dental non-metric traits (Johnson and Lovell, 1994; Prowse and Lovell, 1996) have shown that the individuals buried in Cemeteries B and G are not epigenetically distinguishable; therefore the remains of these two cemeteries have been grouped for further analysis. This made it possible to use Fisher's Exact Test, which is applicable to 2 x 2 contingency tables, to compare very small subsamples (where at least one expected value fell below 5). Other statistical tests that were used to identify intra- and inter-cemetery patterns included the chi-squared test and the chi-squared test with Yate's correction for continuity when comparing small subsamples, the latter used when at least one expected value fell below 10.

Results and discussion

Occlusal macrowear

In all three cemeteries, the majority of teeth exhibited slight occlusal wear, with molars displaying the most cases of severe wear (table 2). Indeed, none of the observable incisors and canines exhibited occlusal wear scored as severe. Statistically insignificant differences in the severity of wear were seen when the age categories were compared, although the teeth of younger adults showed markedly less severe wear, and the teeth of older adults in the non-elite cemetery sample more commonly displayed severe wear. The teeth of males tended to have more moderate and severe degrees of occlusal wear than did those of females.

Antemortem tooth loss

Table 3 presents the tooth count and individual count results for AMTL at Naqada. Overall, males and females were found to have comparable rates of AMTL (35% and 33% respectively), and more than 80% of older adults had lost at least one tooth antemortem. Individuals in Cemetery T suffered less AMTL but the difference is not statistically significant; this result may be an artifact of small and unequal samples.

The ultimate cause of AMTL may be difficult to identify: severe tooth wear may lead to dislocation of a tooth and may cause a tooth's anchor in the alveolus to be tenuous. In addition, carious invasion of the pulp chamber of a tooth may lead eventually to granulomata, abscesses, and cysts that lead to loss of alveolar bone in the periapical

region. Several individuals in the Naqada sample exhibit wear so severe that the tooth roots functioned in occlusion, but the wear occurred slowly because secondary dentin filled in the pulp chamber as the wear progressed, preventing carious bacteria from entering the tooth and leading to periapical abscess with subsequent tooth loss.

	Cemeteries B & G				Cemetery T			
	None	Slight	Moderate	Severe	None	Slight	Moderate	Severe
Tooth Class								
Incisor	0	0	0	0	0	0	0	0
Canine	0	0	0	0	0	2	0	0
Premolar	0	12	7	5	0	10	5	2
Molar	0	37	26	10	0	51	19	11
Total	0	50	34	16	0	63	24	13
Sex								
Male	0	23	24	10	0	29	19	13
Female	0	23	10	3	0	30	5	0
Total	0	46	34	13	0	59	24	13
Age								
Older Adult	0	12	17	15	0	22	15	6
Middle Adult	0	18	17	3	0	28	14	9
Young Adult	0	13	4	0	0	7	0	0
Total	0	43	38	18	0	56	29	15

Table 2: Patterns of occlusal macrowear at Naqada (tooth count). Percentages have been rounded to the nearest full number. Some totals ≠ 100 due to rounding.

	Cemeteries B & G			Cemetery T			Total		
	n	N	%	n	N	%	n	N	%
Teeth	159	1070	15	21	189	11	180	1259	14
Individuals	38	104	37	5	25	20	43	129	33

Table 3: Tooth count and individual count patterns of antemortem tooth loss at Naqada, by cemetery. n = number of affected teeth/individuals; N = number of observable teeth/individuals; % = n/N x 100.

Lesions of the Temporomandibular Joint

The age, sex, and cemetery distribution of individuals affected by lesions of the temporomandibular joint is presented in table 4. The overall prevalence of individuals affected by lesions of the TMJ is 31%, which is slightly smaller than frequencies reported for other ancient Egyptian samples (Leek, 1972) and Mesolithic Nubia (Greene, 1972). In all but one case the porosity, osteophyte development, and changes in surface

morphology found on the mandibular condyles, glenoid fossa, and eminence are consistent with a diagnosis of osteoarthritis (OA). Figures 1, 2, and 3 show examples of the TMJ alterations that have been classified as representative of OA.

A noninflammatory disorder, OA is characterised by 1) destruction of the disc that cushions the articulation of the mandibular condyle with the glenoid fossa of the temporal bone, 2) resorption and proliferation of bone on the mandibular condyle and the glenoid fossa, and 3) lesions of the convex articular eminence that lies anterior to the glenoid fossa. The precise cause of TMJ lesions is difficult to ascertain, in large part because the anatomy of the TMJ is very complex, a combination hinge and sliding joint that is further complicated by the presence of a fibrocartilaginous disc rather than a hyaline cartilage disc, and by the relationship between the joint and the dentition. Despite these unique characteristics, the TMJ shares features with other synovial joints, such as a fibrous joint capsule, connective ligaments, and lubrication by synovial fluid.

	Cemeteries B & G			Cemetery T			Total		
	n	N	%	n	N	%	n	N	%
Age & Sex									
Female									
Young adult	0	7	0	0	1	0	0	8	0
Middle adult	2	8	25	3	7	43	5	15	33
Older adult	5	14	36	0	4	0	5	18	2
Male									
Young adult	2	7	29	0	0	0	2	7	29
Middle adult	8	25	32	2	6	33	10	31	32
Older adult	10	26	39	4	11	36	14	37	38
Total	27	87	31	9	29	31	36	117	31

Table 4: The age, sex, and cemetery distributions of TMJ lesions at Naqada (individual count). n = number of affected individuals; N = total number of individuals; % = n/N x 100. Percentages have been rounded to the nearest full number.

The frequency of TMJ lesions increases with age, for both sexes and both cemetery groups, but very small subsamples prevented a statistical assessment of the effects of age on the prevalence of TMJ lesions. Although advanced age is not a primary cause of TMJ lesions, it is considered a predisposing factor because of the cumulative effects of loading of the joint and the tendency of the disc to become irreparably fatigued and weakened. The relationship between the joint and the dentition is altered by malocclusion, tooth wear, and AMTL. Loss of vertical height occurs with aging as the occlusal surfaces of teeth become worn, and this loss of height can be a significant factor in altered biomechanics at the TMJ. Vertical height often is maintained, however, by overeruption of the teeth involved, which is made possible by the deposition of cementum at the root apices. (This phenomenon can be seen in skeletal remains as the cemento-enamel junction becomes more distant from the alveolar margin, but it must be differentiated from the resorption of the alveolar margin that occurs due to periodontal disease). The early antemortem loss of a tooth, with the continued eruption of the opposing tooth, or the dislocation of

adjacent teeth, also can affect the biomechanics of chewing. Sheridan and co-workers (1991) found a highly significant relationship between long-term tooth loss and TMJ disorders in Medieval Nubians. In response to such changing biomechanical stresses, the TMJ remodels as it attempts to maintain the form and function of the joint.

Regrettably, the incomplete nature of most of the dentitions from Naqada made a detailed assessment of the relationship between malocclusion and/or occlusal wear and TMJ lesions difficult. Indeed, an examination of the individuals in which TMJ lesions were exhibited shows that 18 individuals with OA lesions in one or both glenoid fossae did not have an associated mandible. In general, AMTL and severe occlusal wear were not associated with TMJ lesions, but, this intrapopulational pattern may be deceiving and a more focused assessment of individual cases may prove to be informative in this regard. Perhaps illuminating is the fact that three of the four individuals with what was classified as severe OA lesions at the glenoid fossae had occlusal wear of the first molars that was scored as stage 7 or 8 (i.e., severe). Although Sheridan and co-workers (1991) did not find a correspondence between occlusal wear and TMJ lesions among Medieval Nubians, Hodges (1991) observed a clear association between these variables in a series of ancient British skeletal remains.

Figure 1: Resorption on the right articular eminence (basilar view of the cranium), classified as a 'slight' degree of osteoarthritis.

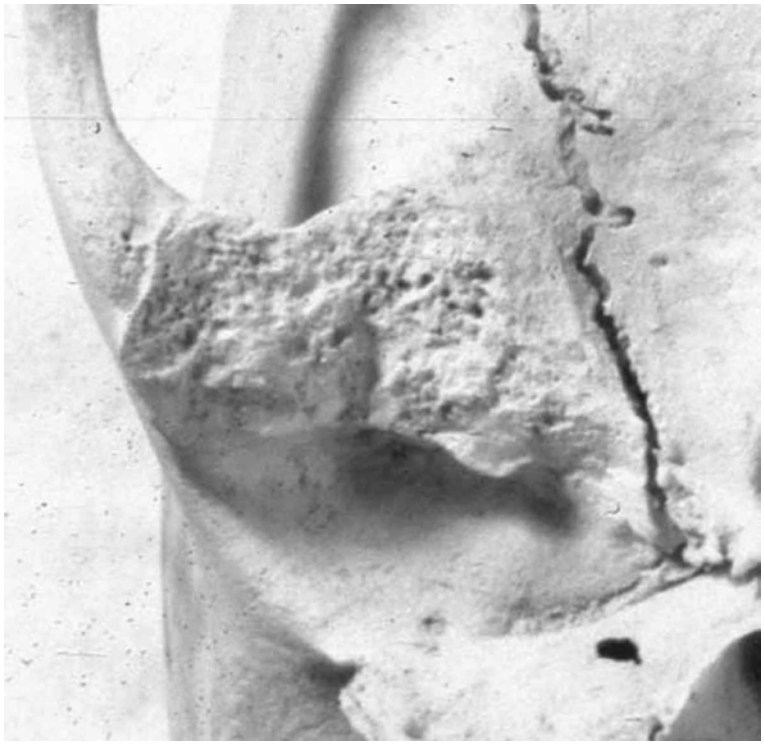

Figure 2: Extensive resorption and marginal lipping on the right articular eminence, classified as 'moderate' osteoarthritis.

Males and females in the young adult category could not be compared because of missing values, but when the sexes in other age classes are compared there is no statistically significant difference in the frequency of TMJ lesions when the cemetery is controlled.

As with the results obtained for an analysis of sex differences in the frequency of TMJ lesions, there is no statistically significant difference between the frequency of TMJ lesions among the individuals buried in the elite versus non-elite cemeteries. When severity of TMJ arthritis is considered, however, three of four individuals with severe lesions came from Cemetery B/G and only one was from Cemetery T, a pattern that cannot be explained by age differences. While it might be supposed that differences would exist because of differences in diet, i.e., with non-elites consuming a diet that included coarser foods, any dietary difference was not translated into observable differences in the overall pattern of osteoarthritis at the TMJ. There are (at least) three explanations for this: 1) social stratification, and hence dietary difference, was not as pronounced during the ancient Egyptian Predynastic period as it was during later periods of pharaonic rule; 2) the individuals buried at Naqada were exposed to other causes of TMJ arthritis, such as parafunctional activities like bruxism, regardless of their status; and 3) the causes of TMJ lesions may have been different for elite and non-elite individuals, but the end result was the same.

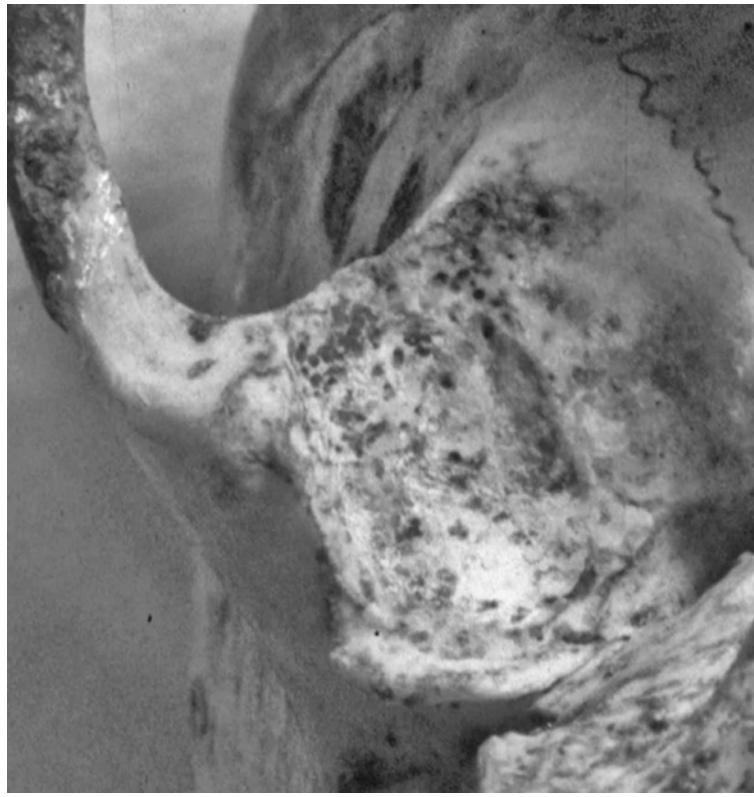

Figure 3: Pronounced remodelling of the right glenoid fossa with the formation of grooves and eburnation, classified as 'severe' osteoarthritis.

One unusual display of TMJ lesions was found in an individual from Cemetery T. Regrettably, the associated mandible was not available for examination, but both glenoid fossae exhibit what appear to be incipient ankylosis resulting from ossifications within the joint that were broken repeatedly during movement of the mandibular condyles (figure 4). A number of potential causes of these lesions were considered; it is widely reported in the clinical literature that TMJ ankylosis is most commonly a unilateral occurrence and usually is due to trauma to the mandible, infection (from the middle ear and mastoid), or a congenital condition such as bifid mandibular condyle. Without a mandible to examine, the identification of a definitive diagnosis is beyond the scope of this paper, but an inflammatory form of arthritis or a pathological condition affecting the fibrocartilaginous disc must be considered in the differential diagnosis.

Conclusions

No statistically significant differences in the prevalence of TMJ arthritis were detected when males and females were compared. Nor were differences detected between the elite and non-elite cemetery samples. The frequency of TMJ lesions increases with age, for both sexes and both cemetery groups, but this association was not statistically significant.

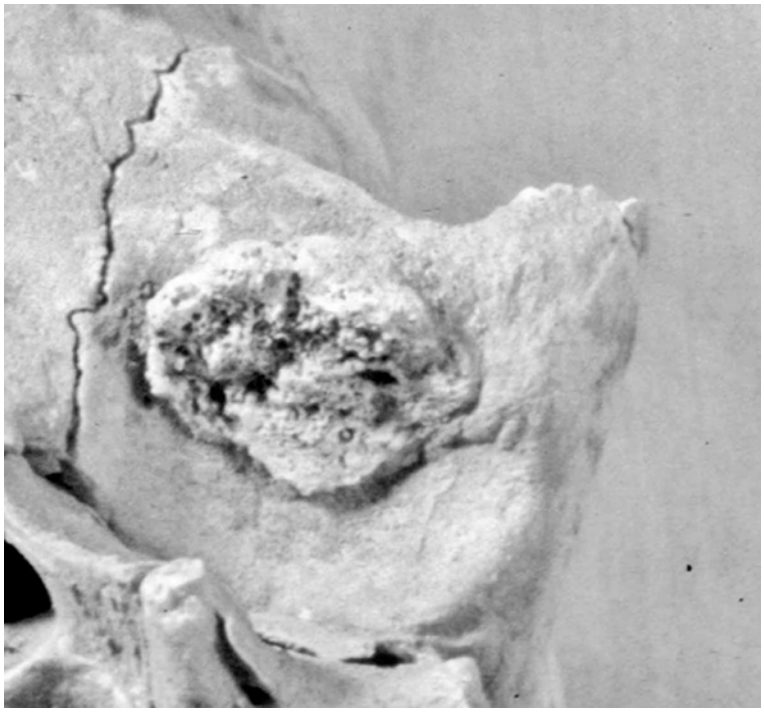

Figure 4: Proliferation of bone within the left glenoid fossa.

Regrettably, the incomplete nature of most of the dentitions from Naqada made a detailed assessment of the relationship between malocclusion and/or tooth wear and TMJ lesions difficult. In general, however, AMTL and occlusal wear were not associated with TMJ lesions: comparisons of average AMTL frequencies and of average occlusal wear scores between individuals with and without TMJ arthritis revealed no statistically significant differences. Since occlusal wear is severe in many individuals, however, it seems likely that a reduction in vertical occlusal height affected TMJ function, and a more focused assessment of individual cases may prove to be informative in this regard.

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