Bioarcheological Report
For the 2009 Amarna South Tombs Cemetery Skeletal Analysis
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Introduction

Analysis of the skeletal material recovered during the fifth excavation season of the Amarna South Tombs Cemetery was conducted from 13 May to 8 June 2009. The analysis was directed by Dr. Melissa Zabecki, Dr. Gretchen Dabbs, and Professor Jerry Rose, who were assisted by a team from the University of Arkansas including Amy Chancellor, Nicole Fumo, John Gorski, Jessica Kinsey, Sean Lee, Andrew LoPinto, Daniel Neubauer, Ronald Pursley, Brad Rega, William Schaffer, Bryony Simmons, and Blair Viguet.

Research questions that drove the analyses were continuously developed and modified based on the past four years’ analytical results, and specialized projects were introduced to enhance the analysis. As in previous years, the peculiar demographic profile with high juvenile deaths was a priority. The frequent spinal trauma and extensive evidence of childhood dietary deficiencies, remained a major concern. To follow up on our understanding of these issues of poor childhood health and nutrition, analysis of indicators of childhood stress, such as rates of cribra orbitalia, enamel hypoplasias and skeletal growth rates, were conducted. All routine skeletal data sets, such as age, sex, and the presence of pathological lesions, were collected by the team. Additionally, specialized projects focusing on the reconstruction of the behavioral patterns necessitated collection of data on the size of adult long bones, variation in muscle attachment sizes, and x-rays to determine cortical thickness of the bones. Appropriate analyses will be undertaken to address our research questions during the coming year while available preliminary results are presented in this report. This report is a product of contributions from all team members during the 2009 season.

Methods

The excavated skeletal material was organized in the lab by excavation units, so the skeletons could be analyzed within their archaeological context, and so bones dispersed by ancient grave robbers could be reunited to their skeletons. All of the skeletal materials was cleaned by dry brushing with soft brushes. This was performed over a plastic basin to catch any cultural and biological material that may have been mixed with the sand. This detritus was regularly screened to recover meaningful elements. Nonosseous biological material such as hair, body tissues, and fingernails, as well as all cultural material, such as linen, matting, and pottery, was bagged with labels stating the provenience and set aside for future analysis by specialists within each field.

After cleaning, basic data collection was conducted following the protocol specified by Buikstra and Ubelaker (1994). Included in this data are bone and tooth inventories, age and sex estimations, bone and tooth measurements, and pathological observations. Additional specialized data were collected according to individual protocols published in recent research publications. Data for these special projects was collected on material from the entire Amarna South Tombs Cemetery sample, excavated from 2006 to 2009. We would like to thank our SCA inspector, Mr. Walaa Mostafa Mohammed Ali, for allowing us access to the previously
excavated material, recovered from 2006 to 2008. The additional data greatly enhanced each study by making the sample size larger, which allowed the results to be more meaningful.

Craniometric data, consisting of 82 measurements and eight observations of morphological traits, were collected from the skulls. These data will be used to analyze skull shapes to define possible regions of origin for individuals in the sample. Cervical diameters of the permanent teeth from all adult skulls were taken. The measurements taken on adults of known sex will be used to design a multivariate formula which will allow for sex estimation based on tooth size for individuals without os coxae, the bones traditionally used to estimate sex. Biomechanical measurements of femora and humeri were taken, along with x-rays of the bone shafts, to measure the thickness of the bone cortex. These data can be used to reconstruct the extent of use of the legs and arms.

Results and Discussion

The 2009 excavations of the Amarna South Tombs Cemetery were conducted in two locations of the cemetery. In one location, excavations continued in the same area as previous years, at the site now referred to as the upper cemetery location. In 2009, a strip of seven 5m x 5m squares was opened adjacent and north of those opened in 2006-2008. In the other location, a strip of six 5m x 5m squares was opened in a new area to the north, near the mouth of the wadi. This area is now referred to as the lower cemetery location. In total, 62 individuals, 13 isolated skulls, and four isolated mandibles were excavated from both areas.

The condition of the skeletal material varied greatly from very well preserved to salt-encrusted and sun-bleached bone (thrown to the surface by ancient tomb robbers) lacking any organic matrix. The maximum amount of information was gathered from each bone regardless of its condition, but some data including simple age and sex determinations for certain individuals were impossible to collect due to the poor preservation of some of the bone. This differential preservation complicates the integrity of any archeological skeletal sample, and the total number of observations reported for individual analysis types will vary as a result.

The re-examination of all skeletal remains excavated since 2006 enabled the team to conduct analysis and interpretation on the totality of the Amarna South Tombs Cemetery sample. The demography of the South Tombs Cemetery is presented separately for the lower and upper cemetery locations, but it is important to keep in mind that the lower cemetery location is a limited sample, since it has only been excavated for a single season. Figure 1 shows the age categories at death for the lower site in green. This reveals many deaths from birth to five years of age, which is normal in ancient societies. The death rate falls to a low between 5 and 20 years of age, which is again normal for all populations. Finally the death rate begins to rise after age 20 with only a few old adults dying after 45 years of age. Although the length of life for the people in the lower cemetery location is very short, their distribution by ages at death is normal for ancient human populations. In contrast, the upper cemetery location, shown in blue on Figure 1, has fewer deaths after birth than would be expected in a normal population, but the death rate of later childhood (5-20 years of age) remains high. The rate climbs in the 15 to 20 year age group, when death rates should be at their lowest. The adult rate of death after 20 years continues to increase as expected. This is an abnormal age distribution with a large number of deaths between 5 and 20 years of age, when they should be the lowest. The average age of death for all 154 people studied from the South Tombs Cemetery is 22 years. The average age of death of the 88 people who survived
to adulthood is 32 years. Adult women lived to an average age of 34 years, if they lived beyond 18 years. Men reaching adulthood only lived to be 30 years of age.

The uniqueness of the Amarna demography can be most clearly seen when compared to other Egyptian skeletal samples, shown in Figure 2. The mortality profile of Amarna, shown in red, is compared to New Kingdom burials from Tombos (Nubia), Memphis, Qurneh, Shellal, and the Scandinavian Joint Expedition (SJE) (data from Buzon 2004). With the exception of the birth to five year category, where few infants were found at the other sites, Amarna looks most different during the ages from 5 to 20 years of age, where Amarna has a much higher mortality rate. Keeping in mind that all groups of people usually have their lowest mortality between the ages of 15 and 20 years of age, Amarna stands out with a very high death rate during this period. This clearly indicates the living conditions were poor at Amarna, resulting in premature deaths of many young people, possibly due to disease and poor nutrition.

Adult stature is calculated using a formula designed specifically for ancient Egyptians (Raxter et al. 2008). The average male stature of all South Tombs Cemetery skeletons is 163cm (5'4"), while the female mean is 153cm (5'0''). Excavation of the upper cemetery location of the cemetery has continued for four years and has a much larger sample size. The mean male height at the upper cemetery location is 163cm, while that of the males from the lower cemetery location is shorter at 161cm. The female average from the upper cemetery location is 154cm, while those from the lower cemetery location average only 151cm. The sample size for the lower cemetery location is very small, so no significance can be attributed to the differences at this time.

Mean maximum femur lengths have been published by Zakrzewski (2003) for Egyptian skeletal collections dating from the Predynastic to the Middle Kingdom, and these have been converted to heights for comparison with Amarna. Stature in Egypt has followed a consistent trend of increasing heights for both males and females from the Badarian Period to the Early Dynastic, as agriculture became more efficient. Then, stature began to decrease from the Early Dynastic through the Old Kingdom into the Middle Kingdom as the centralized state matured (Figure 3). The Amarna heights are compared with these data and trends. Because the samples from Amarna (adult individuals with secure sex determination and complete femora) are still few in number, the outliers were removed before determining the average heights used in this comparison. Both the adult male height of 162cm and female height of 153 cm from the South Tombs Cemetery at Amarna are similar to heights in the Middle Kingdom.

This comparison prompts the question of whether life during the Amarna Period was conducive to healthy childhood and good overall growth. In an attempt to answer this question, we can divide the adult population into those older than 35 years at death and those who would have grown up before the Amarna Period, and those younger than 35, who could have completed all or some of their growth just before and during the Amarna Period. Mean height for the males who grew up before the Amarna Period was 165cm, while the mean height for the males who grew up during the Amarna Period was 162 cm. Females experience a similar decline of 3cm, from 154cm for those older than 35 years of age to 151cm for younger adult females. These results tentatively suggest that childhood nutrition and health declined during the Amarna Period.
Dental development is the standard method for the determination of juvenile age as it is least sensitive to disease, malnutrition, and other stressors, which together reduce ultimate adult stature. The difference between biological age (derived from dental development standards) and long bone length, yields key information about nutrition, growth and development, and overall health of young individuals. When compared to standard growth curves from modern, well-nourished, healthy populations (Maresh 1970), it is clear that the juveniles at Amarna were not developing at a normal rate. When coupled with the pathological analysis of the skeletal material, it is apparent these juveniles were in fact affected by disease, malnutrition, and many other environmental stressors, which led to an overall stunted juvenile population and relatively high occurrence of juvenile death. Those individuals surviving to adulthood had short statures, resulting from these hardships during the growth period. The growth chart of the femur (Figure 4) shows the Amarna juveniles below the standard curve, and supports a positive association between poor juvenile health and nutrition and short adult stature.

There is other evidence of childhood stress at Amarna. Deficiencies in certain nutrients, like iron, Vitamin C, and Vitamin D, can leave very specific markers in the form of porosities (small holes) on the skull. Cribra orbitalia, fields of small and usually uniform pinholes in the eye orbits, is one such condition (Figure 5). Sixty-one percent of the 36 juvenile skulls observed exhibit cribra orbitalia, documenting dietary deficiencies and childhood disease, such as diarrhea. Adult skulls exhibit the healed lesions, reflecting their experience with childhood nutritional deficiency. Of the 73 complete adult skulls observed, 25% display cribra orbitalia. The total prevalence of cribra orbitalia at Amarna is 31%.

Grooves on teeth, known as enamel hypoplasia, are the result of childhood disease suffered under conditions of poor nutrition (Figure 6). Fifty-eight percent of the adult individuals at Amarna had at least one hypoplasia. In other words, over half the adults at Amarna suffered, and survived at least one serious incident of childhood disease during a time of under-nutrition.

The adults at Amarna also experienced spinal stress. Schmorl’s nodes are a depression in the body of a vertebra that fills with hard, dense bone. These result from extreme compressive force to the vertebral column, such as those that might occur while carrying heavy load, which ruptures the fluid filled sacs between the vertebrae. This fluid can damage the vertebrae, resulting in the formation of a Schmorl’s node. Forty-nine percent of the individuals analyzed from Amarna had Schmorl’s nodes, which indicates that the population as a whole experienced a great deal of back strain throughout their lives.

Of the individuals recovered from both cemetery locations of the Amarna South Tombs Cemetery, 31, or 20%, had relatively complete dentitions, with both upper and lower jaws, and most teeth. Seventy-one percent of all dental arcades observed showed some form of misaligned, rotated, or crowded teeth. These individuals could have used the services of an orthodontist had they lived today. This crowding is clearly caused by deficient growth of the lower jaw (the mandible). This is consistent with the deficient growth displayed in the long bones. In Figure 8 below, the mandible on the left shows all teeth properly aligned, while the front teeth on the right are crowded.

Dental health was examined at Amarna. There were 29 children under 12 years of age who had sufficient teeth for examination. Only two of these showed dental decay. There were 107 sets of adult teeth, and 38% had one or more cases of decay as shown in Figure 9. This is
a very low rate of decay for an agricultural population. Infection of the dental pulp (abscesses) that eventually result in tooth loss was found in 30% of the mouths. That 75% of these also had tooth decay suggests that decay was the primary cause of abscess and ultimately tooth loss.

A paleopathological survey of all skeletons demonstrates that the majority of skeletal lesions at Amarna resulted from hard work and accidents. The spine exhibited the most fractures, with 30% of the males, and 38% of the females exhibiting at least one healed fracture for a total incidence of 28%. The lower arm (ulna) was fractured in 13% of the males and 19% of the females for a total incidence of 16%. Arthritis was found in 44% of the females and 56% of the males for a total of 48% with degenerative joint disease.

Conclusions

The large, experienced team of the 2009 analysis season re-examined the entire skeletal sample from the Amarna South Tombs Cemetery. Moreover, the team re-associated legs, arms, mandibles, and skulls, which had been scattered by ancient grave robbers, with their original owners. The demography continues to show an excess of deaths between the ages of 5 and 20 years, when mortality should be lowest. Interestingly, the lower cemetery location, with its much smaller sample size, displays a normal demographic curve with low mortality between 5 and 20 years. The high juvenile mortality shown in the upper cemetery location strongly suggests the presence of epidemic disease.

Poor nutrition at Amarna is demonstrated through a number of evidential lines. Nutritional deficiencies of vitamins and protein are evidenced by high rates of cribra orbitalia, enamel hypoplasias, sub-normal long bone growth rates, and short adult statures. That adults who experienced growth before the Amarna Period are taller than those who grew up during the Amarna Period suggests childhood nutrition declined over time.

Life at Amarna was physically demanding. The high frequency of spinal injuries and arm fractures suggests accidents while working with heavy loads. The high rate of degenerative joint disease indicates regular hard work.

Future excavations in additional sections of the cemetery would greatly contribute to the reconstruction of the events that occurred at Amarna.

Citations


Figure 1: Graph showing the demography of the South Tombs Cemetery individuals.

Figure 2: Graph showing the demography of the South Tombs Cemetery compared with other Egyptian Samples.
Figure 3: South Tombs Cemetery stature shown with comparative samples’ stature.

Figure 4: Comparison of Amarna versus un-stunted juvenile femoral growth.
Figure 5: Photograph showing skeletal lesions in left eye orbit left by cribra orbitalia.

Figure 6: Photograph of mandible displaying enamel hypoplasia.
Figure 7: Photograph of lumbar vertebra displaying Schmorl’s nodes.

Figure 8: Photograph of two mandibles displaying normal tooth alignment (right) and crowding (left).

Figure 9: Photograph of mandible with tooth decay and antemortem loss of teeth.