# Fractured Childhood: A Case of Probable Child Abuse from the Kellis 2 Cemetery, Dakhleh Oasis, Egypt

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## Introduction

Much can be learned about cultural attitudes of violence towards children from the analyses of their skeletal remains and mortuary patterns of the communities in which they were born, lived and died. A bioarchaeological approach integrating biological, socio-cultural, and physical environments is used in analyzing a young child from Kellis 2, a Roman Period (c. 50-450 AD) cemetery located in the Dakhleh Oasis, Egypt. The purpose of this study is to highlight a probable case of malintent towards a young child in an archaeological context, thus giving the incidence of child physical abuse considerable time depth, as this may be the earliest documented case. This child (B519), aged two to three years, exhibits skeletal fracture patterns consistent with chronic physical abuse, which may or may not have led to the child's untimely death. Macroscopic, radiographic, histologic and isotopic analyses were used to determine if any physical effects of abuse were reflected in this child's remains. Results from our investigation support this diagnosis. This case presents an opportunity to address questions concerning attitudes towards children, their social experiences, and quality of life during the period of Roman rule in Egypt.

## Kellis 2 Cemetery

Dakhleh Oasis is located approximately 250km west of the Nile Valley and is one of five major depressions in Egypt's Western Desert (Fig. 1). The ancient town of Kellis (*Ismant el-Kharab*) is located along an ancient desert trade route that runs through the Oasis and likely housed several thousand people at its zenith in the 4th c. AD. Kellis was considered an important economic and political hub during this period.[1] The Kellis 2 cemetery extends for at least 150 m east-west and 60 m north-south and is characterized by the presence of mud-brick enclosures, low mud-brick mastaba-like superstructures and is densely filled with simple rectangular pit graves dug into the hard-packed red Nubian clay (Fig. 2). The cemetery appears to be based on familial and accretionary patterns surrounding tomb structures. Bodies are placed supine with the head to the west and feet to the east, with arms to the sides or over the pelvic region, and feet placed side-by-side or crossed. Individuals are typically wrapped in linen shrouds and bound by linen cords.

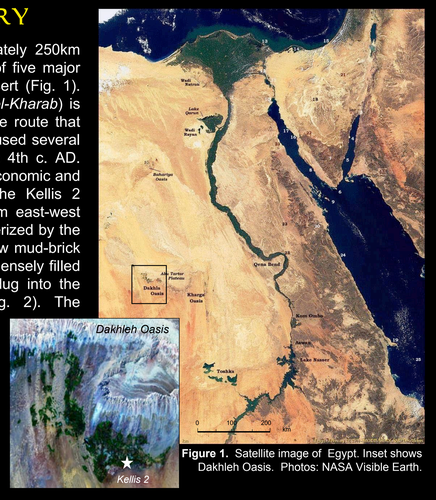


**Figure 1.** Satellite image of Egypt. Inset shows Dakhleh Oasis. Photos: NASA Visible Earth.

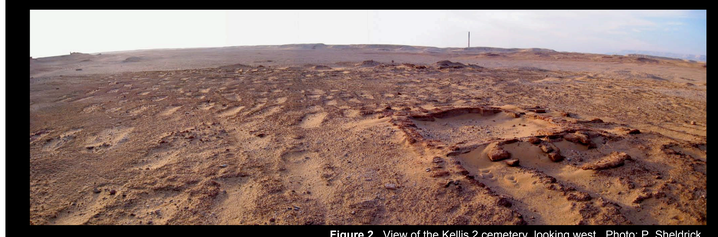

**Figure 2.** View of the Kellis 2 cemetery looking west. Photo: P. Sheldrick.

## Methods

**Macroscopic & Radiography:** This child was aged between 2-3 years using a combination of diaphyseal length, epiphyseal and dental development. Detailed macroscopic observations of skeletal lesions and fractures were recorded using an Advantix Fuji Nexia 400 digital camera with a macro lens. Lesions and fractures were explored in further detail using an Olympus SZX9 stereoscope with a cold light source. Digital images were captured at 6.3x and 10x magnification using a CoolSnap-Pro *cf* digital camera mounted to the stereoscope. Plain film radiographs were taken of all skeletal elements using a Faxitron X-ray Cabinet System with Kodak EC1 film (90 seconds at 60kVp and 0.3mA). No screens were used as image quality was found to be superior without.

**MicroCT & Histology:** Micro-computed tomography (MicroCT) was used as part of an exploratory, non-destructive methodology to assess using this method in distinguishing various types of periosteal reactions. A GE Medical Systems Scanner (80 kVp and 450 mA in 2x2 bin mode, 45μ slices) and MicroView 2.0.29 viewer were used to visualize the bony reactions on the left humerus. For histological analysis, a small section of bone was cut from the mid-region of the right 11th rib and was cleaned and dehydrated using an ascending ethyl alcohol series to remove excess moisture and facilitate complete infiltration of the methylmetacrylate resin. Thin sections (70-100μ) were produced from the embedded rib using a Buehler Petrothin system. Microscopic analysis was conducted under polarized and plane light using an Olympus BX41 upright microscope and mounted digital camera. A hilfsobject red 1st order quartz compensator (Olympus model U-P521) was used similarly to polarizing lenses (Maltese cross pattern in secondary osteons can be seen), aiding in the visualization of collagen bundles and "products of diagenesis".[2] Histological images were captured at 40x and 100x magnification.

**Isotopic Analysis:** Isotopic analyses of skin, hair and nails were conducted at the Laboratory for Stable Isotope Studies, University of Western Ontario using a Costech elemental analyzer interfaced with a Thermo Finnigan Delta$^{plus}$ XL continuous flow isotope ratio mass spectrometer. Hair samples were cleaned using 2:1 methanol and chloroform solution, nails and skin were cleaned using 2:1 chloroform and methanol solution. All samples were rinsed and sonicated in deionized and distilled water for 30 minutes, dried for 48 hours at 50°C, then pulverized prior to weighing. Diagenesis was determined by carbon to nitrogen ratio. All samples for this study fall between 2.9 and 3.6 C:N. Duplicate precision for the analyzed tissues was ±0.2‰ for $\delta^{13}C$ and ±0.3‰ for $\delta^{15}N$ .

## Macroscopic analysis & Radiography

Distribution of fractures and subperiosteal new bone formation (SPNBF) for this child are shown in figures 3 and 4. Active cribra orbitalia was noted in both orbits (Fig. 5a), as well as slight SPNBF on the temporal and zygomatic processes (Fig. 5b), and on the medial and lateral surfaces of the mandibular condyles (Fig. 6). The humeri exhibit complete bilateral fractures of the proximal third of the diaphyses. A callous of new bone bridged across the fracture site on the left humerus, suggesting that the fracture occurred at least 1-2 weeks prior to death.[3] Evidence of healing is apparent on the margins of both fractures as well as in trabecular bone within the proximal portion of the humeri (Fig. 7a & b). Periosteal reactions encircle the diaphysis of the right radius (Fig. 8) and distal portion of the ulnar diaphyses exhibit asymmetrical new bone formation. There is a complete fracture of the medial aspect of the right clavicle with no evidence of healing (Fig. 9), indicating a perimortem occurrence. Both scapulae have SPNBF on the ventral and dorsal surfaces, most prominently at the medial borders and superior and inferior to the spinous processes (Fig. 10). Two well-healed fractures are evidenced on the 7th left and 8th right ribs by hard callous formations. Most ribs exhibit periosteal reactions on the external and visceral surfaces in varying degrees, although lower ribs exhibit the most pronounced new bone formation (Fig. 11).

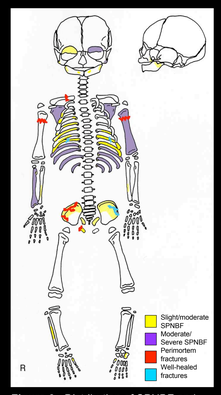


**Figure 3.** Distribution of SPNBF and ante- and perimortem fractures.

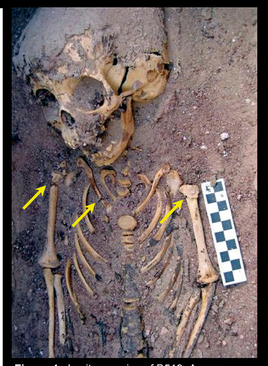

**Figure 4.** In situ remains of B519. Arrows indicate perimortem fractures. Photo: T Dupras.

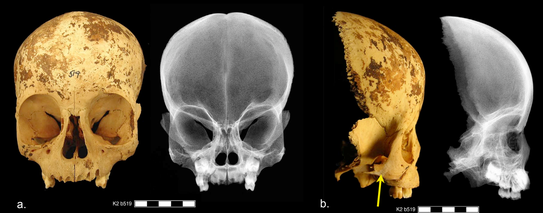


**Figure 5.** a) Photograph and x-ray showing active cribra orbitalia in both orbits; b) Arrow pointing to slight SPNBF on zygomatic process.

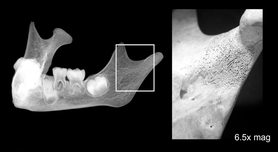


**Figure 6.** X-ray and photograph of mandible with detail of medial portion of ramus.

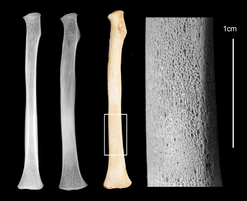


**Figure 8.** AP & lateral x-ray and photograph of right radius with detail of periosteal reaction.

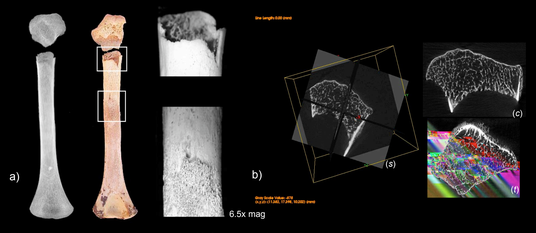


**Figure 7.** a) X-ray and photograph of left posterior humerus with detail showing fracture and circumferential SPNBF; b) MicroCT image capture (GEMS MicroView 2.0.29) of proximal portion of humerus, insets showing sagittal (*s*), coronal (*c*) and transverse (*t*) planes.


**Figure 9.** X-ray and photograph of right clavicle with detail of complete fracture of medial aspect.

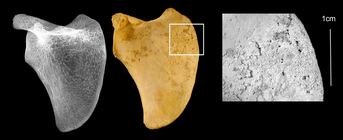


**Figure 10.** X-ray and photograph of right scapula with detail of SPNBF on anterior surface.

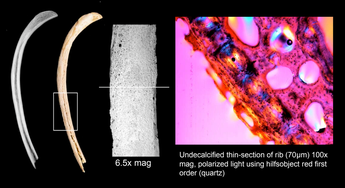


**Figure 11.** X-ray and photograph of right 11th rib with detail of SBNBF on pleural surface and thin section.

The right ilium exhibits plastic deformation on the superior aspect of the iliac wing (Fig. 12). This fracture shows little to no evidence of healing, indicating a perimortem occurrence. The acetabular surface of the right pubis exhibits a fracture in the early stages of healing. In addition, the left ilium exhibits a healed compression fracture on the superior aspect of the iliac wing along with SPNBF anterior to the healed fracture. There are also periosteal reactions along the margins of the iliac crest on both iliae and on the right ramus of the ischium. SPNBF is also seen on: both femora on the anterior proximal neck and distal metaphyses; the left tibia on the medial diaphysis; the right fibula on the anterior border; the calcani on the floor of the sinus tarsi; and the metatarsals on proximal plantar surfaces.

## MicroCT & Histology

The left humerus also exhibits circumferential SPNBF. MicroCT of the left proximal humerus aided in visualization of a sclerotic margin directly beneath the affected area previously described, which was not readily apparent in standard radiographs. New bone formation appears proliferative and unorganized, indicating a rapid occurrence, probably as a response to trauma. Histologically, SPNBF is proliferative in nature, rather than osteolytic, as no resorption or destruction of the underlying cortex has occurred. The reactive bone is comprised of woven bone (disorganized and non-lamellar) and resembles a "roman aqueduct" formation.[2] Microscopic examination revealed that SPNBF was deposited on the periosteal surface, rather than emerging from underlying cortical bone. This new bone formation, being separate from the underlying cortex, implies a non-inflammatory and most likely hemorrhagic origin (Fig. 7b).

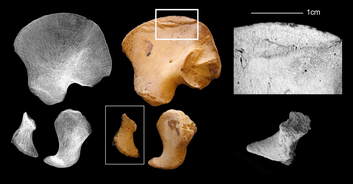


**Figure 12.** X-ray and photograph of medial aspect of right ilium, pubis and ischium with detail showing plastic deformation on iliac crest and healing fracture of the acetabular surface of the pubis (lateral view).

## Isotopic Analysis

Isotopic analyses of hair, skin and nails were used to determine if any physical effects of abuse were reflected through nutritional metabolism over time. Hair, nail and skin were analyzed for stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotopes and compared with those of other children from K2 (Fig. 13).[4] Hair provides values 1-2 months prior to death, while nail represents a few months previous and skin approximately a year previous in the child's life. The $\delta^{13}C$ values from B519's tissues at the time of death generally fall within the range of variation for other children aged between birth and 4 years; however, the hair value approximately 2 months prior to death lies outside the range suggesting the possible use of illness food (i.e., millet gruel) followed by an increase in protein intake.[4-5] Variations exist in the $\delta^{15}N$ values between tissues as well as the comparative ranges. The $\delta^{15}N$ value for skin suggests that the child was breastfeeding at least one year prior to death and the nail value falls within the range for the child's age group; however, $\delta^{15}N$ value for hair drops by almost 6‰ from the skin value, which cannot be accounted for by weaning alone. In response to trauma or infection, or if the intake of protein is inadequate, there is a net loss of nitrogen in the body. The hair values for B519 strongly indicate a response to injury (e.g., fractures and/or chronic trauma) involving ingested dietary protein as the osteoid source for new bone formation[6]; however, additional metabolic disorders involving $^{15}N$ are being investigated.[4]

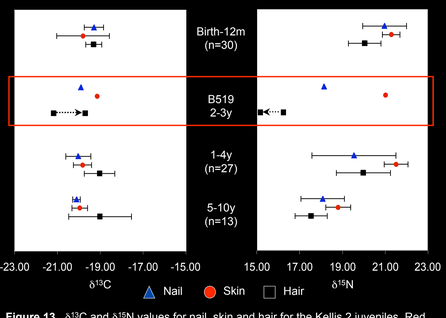


**Figure 13.** $\delta^{13}C$ and $\delta^{15}N$ values for nail, skin and hair for the Kellis 2 juveniles. Red outline shows values for B519. Dotted arrows show change in hair values over last two months of the child's life.

## Child Abuse?

The pattern of fractures and periosteal lesions seen in this individual are suggestive of s malintent trauma. Clinically, humeral fractures are frequently associated with child abuse.[7] Alth fractures of the proximal humerus most often occur in younger individuals, a directed high-e trauma is needed to produce the type of fractures like those seen in this case.[8] Furthermore, Sl on the diaphyses of the arms is consistent with stripping of the periosteum from bone when an a leg is used as a handle.[9] Although fractures of the clavicle are the most frequent childhood fract clinical cases, fracture of the medial 1/3 portion occurs infrequently (only 5% of clavicular fract whereas fractures of the middle and lateral 1/3 portions are more common.[10] Rib frac particularly in differential stages of healing, are regarded as virtually diagnostic of child abuse, a are seldom seen in infants and young children even in response to violent trauma (e.g., accidents). The pattern of fractures and differential stages of healing in the pelvic bones in multiple traumatic events. Significance of these fractures is unclear because there is a dea clinical reports on matters regarding child abuse. However, fractures of this type almost always from high-energy directed forces. In clinical settings, close scrutiny of the pubic rami is sugges Histologically, while reactive bone on the ribs appears to be the result of non-severe hemorrha humeral periosteal reactions suggest that trauma was more severe in the long bones as the re bone formed a disorganized, sunburst-like pattern. The essential natures of the reactions were similar in that they were non-inflammatory (infectious) proliferative reactions and most lik hemorrhagic origins, which suggests trauma as its etiology.

| Condition | Presence | Condition | Presence |
|---|---|---|---|
| **Physiologic SPNBF** | | **Infantile cortical hyperostosis** | |
| <6 months | - | <6 months | - |
| Diaphyseal involvement | + | Severe SPNBF | - |
| Single-lamellar bone | - | Mandibular involvement | + |
| | | Bilateral involvement | + |
| **Leukemia** | | Unilateral ribs/mandible | - |
| SPNBF | + | Diaphyseal fracture | + |
| Leukemic lines | - | | |
| Osteolytic lesions | - | **Scurvy** | |
| Anemia | + | Diaphyseal fractures | + |
| Osteopenia | - | Osteopenia | - |
| Sclerotic lesions | - | Large callus | - |
| | | Bilateral involvement | + |
| **Osteogenesis imperfecta** | | Metaphyseal iregularity | - |
| Osteopenia | - | | |
| Dental malformation | - | **Rickets** | |
| Diaphyseal fractures | + | Diaphyseal fracture | + |
| | | SPNBF | + |
| **Brittle bone disease** | | Metaphyseal irregularity | - |
| <1 year | - | Osteopenia | - |
| Rib fractures | + | | |
| Metaphyseal fractures | - | | |

**Table 1.** Differential diagnosis of skeletal diseases associated with fractures, SPNBF, irregular metaphyses, cone-shaped epiphyses alone or in combination.

In order to understand trauma patterns within individuals, it is useful to contextualize those patterns with those of the larger population. Although population fracture data for Kellis 2 is preliminary, only 4% of juveniles analyzed thus far (n=176) exhibit fractures (Table 2). Burial 519 is the only juvenile that exhibits fractures related to malinent trauma. As a whole, this isolated case within the K2 cemetery and the multiple fractures in differential stages of healing, along with the varied degrees of asymmetrical SPNBF, are strongly indicative of chronic physical abuse. However, distribution of SPNBF on the scapulae and mandible may imply that other agent(s) may be involved in addition to the sustained trauma.

| Age Category | # of individuals analyzed | # with fractures | Pre |
|---|---|---|---|
| **Fetal** 0-36 weeks | 17 | 1 | |
| **Perinate** 37-40 weeks | 37 | 0 | |
| **Neonate** 0-12 months | 54 | 2 | |
| **Young child** 1-4 years | 31 | 2 | |
| **Middle child** 5-10 years | 25 | 2 | |
| **Older child** 11-15 years | 11 | 3 | |
| **Total** | **176** | **7** | |

**Table 2.** Prevalence of fractures in the Kellis 2 ju population.

It is also important to be awa conditions that produce skeletal ch similar to those resulting from ph abuse. Differential diagnosis of the sk lesions of child abuse include a vari diseases, including physiologic new formation of infancy, leuk osteogenesis imperfecta, infantile c hyperostosis (or Caffey's Disease), s rickets, and temporary brittle bone di (Table 1).[12] The clinical and archaeol literature reports that hypert osteoarthropathy, hypervitaminosis osteomyelitis, and congenital syphili also mimic child abuse. These diseases were excluded from differential diagnosis because nearly of the classic characteristics of diseases were present.

The dearth of publications concerning child abuse in the historical and archaeological lite cannot be taken as evidence that violence directed at children was a rare occurrence.[14] Ir evidence relating to maltreatment of children in the Roman Empire is not uncommon. The mannered Seneca bluntly recommends that parents should beat a child who is in need of disc whether a slave or freeborn.[13] Given the information reported, it is still not known how these att may have influenced perceptions of childhood and actions of adults in Roman Egypt. It has shown that frequent corporal punishment of children is predicted by higher levels of stratification and political integration, long-term use of an alien currency, and in societies where relative caretakers help raise children. In addition, societies are likely to practice corporal punisl to prepare children for living in a society with native or imposed power inequality.[15] All of indicators have a historical presence during the period of Roman rule in Egypt. Perhaps discov this case signals that some Roman beliefs regarding corporal punishment of children filtere Egyptian practice, or perhaps child maltreatment seems so aberrant from the larger patterns of and attentive care that the few cases found rarely find their way into the literature.

## Acknowledgements

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