One accident too many?

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Introduction

How did he die? This is a frequent question asked of bioarchaeologists when examining skeletal remains and in most cases the answer eludes us. Perhaps a more plausible question would be 'how did he live?' but even then there are limitations to the interpretation of trauma and disease in ancient skeletal remains, particularly episodes of trauma. Healed traumatic lesions, in addition to dental disease and osteoarthritis, are the most frequently observed pathological lesions in ancient skeletal remains, both human and animal. Most individuals who suffered from injury exhibit one or two lesions (fracture, dislocation, or muscle pull), but occasionally an individual is excavated whose skeletal remains are riddled with trauma, which offers an intriguing case study.

One method used by bioarchaeologists to interpret ancient trauma is clinical analogy, because clinicians have the luxury of being able to interview their patients to elicit the cause of their injuries. Bioarchaeologists are not so fortunate and therefore must rely on medical literature, research, and protocols to aid in their descriptions and interpretations of trauma. Bioarchaeologists also use data retrieved from anatomical skeletal collections with known histories. For example, the skeletons of two North American males, known to have engaged in boxing, exhibited an almost identical accumulation of injuries,[1] which generate a set of criteria that might identify ancient people who participated in interpersonal conflicts. While their isolated injuries could not be attributed solely to combat, with the exception of the fractured cheek, nose and ulna fractures, the collection of lesions suggests an aggregate of injuries from boxing or similar activity over a lifetime. Other researchers[2] observed a similar set of injuries among four archaeological skeletons, and, although violence through military conflict was strongly indicated, both scholars cautioned that such an interpretation was purely hypothetical.

This study briefly describes the injuries observed on the skeletal remains of a man who lived during the Kerma Period in ancient Sudan and offers explanations for the discrete injuries based on parallels discussed in clinical literature, particularly literature from non-industrialised regions.

The context

The Northern Dongola Reach Survey, a project sponsored by the Sudan Archaeological Research Society, recorded archaeological sites and monuments over a five-year period of survey from 1993–97.[3] During the 1996/97 season, a small Kerma period cemetery (P37), located south of Kawa, was excavated and 46 individuals were recovered (**Fig. 1**). The Kerma Ancien (*c.* 2500–2050 BC) graves, which had been robbed in antiquity, were identified by a low mounds of soil blanketed by a cluster of white quartzite pebbles that were interspersed with fragments of basalt and a black ferruginous material. The

1 Hershkovitz *et al.*, *International Journal of Osteoarchaeology* 6 (1996), 167–78.
2 Anderson, *Journal of Paleopathology* 7 (1995), 227–35; Wakely, *International Journal of Osteoarchaeology* 6 (1978), 76–83.
3 Welsby, *Life on the Desert Edge.*

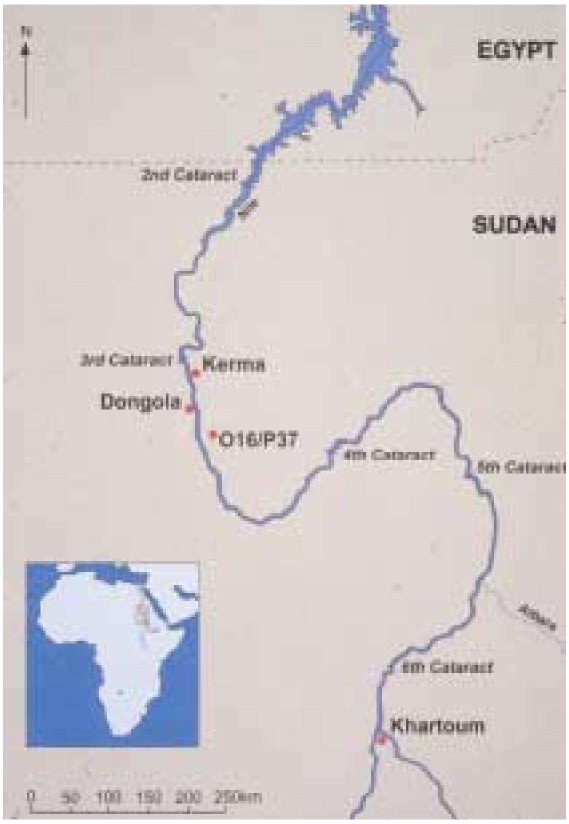

Fig. 1 Map of the Dongola Reach region showing Site P37.

Fig. 2 Skeleton J3-13-44 *in situ.*

individual under study, termed (J3)13-44 [grave (J3)13, skeleton 44], was interred in the tradition of the Kerma Ancien period: the skeleton was laid on its right side in a flexed position, oriented east to west, head to the east and facing north, with the hands placed in front of the face (**Fig. 2**).

The methods reviewed and recommended by Buikstra and Ubelaker[4] were used to establish the age and sex of this individual. The skeletal remains were identified as a male based on the dimorphic characteristics of the skull and the pelvis. Pubic bone degeneration, changes to the auricular surface of the pelvic bone, and sternal rib end modification were used to determine that this individual was 25–35 years of age at the time of death. All of the long bones were present and the bones of the lower leg (tibia and fibula) were chosen to determine the male's stature. Using a regression formula developed by Trotter and Gleser,[5] the stature was established at 165.11 ± 3.53 cm, which fell below the mean of 169.41 ± 5.53 cm for the sample.[6]

4 Buikstra and Ubelaker (eds), *Standards for Data Collection from Human Skeletal Remains*, 16–38.
5 Trotter and Gleser, *American Journal of Physical Anthropology* 16 (1958), 79–123.
6 Judd in Welsby, *Life on the Desert Edge*, 458–543.

Fig. 3 Small puncture lesions on the right parietal and frontal bones.

Archaeological trauma

Before a cultural explanation for trauma as a result of ancient behaviour can be offered, it is essential to determine first if a bone anomaly is indeed due to trauma and then to describe the injury. Trauma is divided into three categories:

- trauma resulting from the presence of another pathological process, for example, bones weakened by osteoporosis are predisposed to fracture,
- microtrauma due to repeated mechanical stress to the musculoskeletal structure over time, and
- macrotrauma, which is attributed to a sudden physical stress.

It is the latter category that is examined here and includes fractures, dislocations, and tears of a tendon or muscle attachment from the bone, which eventually become ossified.

The injuries

All of this man's injuries were healed to some degree. Healed lesions on bone are identified in several ways: by a visible callus formation; through an angular deformity created by the fractured ends of the bone, which may appear as a fracture line on a radiograph; by a non-union of healed bone at the fractured ends; or in the case of the skull, the edges are sealed or bevelled by bone remodelling.

The skull

Radiographs did not reveal any evidence of major traumatic skull injury. The right side of the skull vault, however, exhibited six small, superficial, oval-shaped lesions that ranged from 27–38 mm^2 in area and were up to 3 mm deep (**Fig. 3**). These lesions had puckered bevelled edges indicating that some healing had occurred.

Fig. 4 Spinous process injuries of vertebral column.

Fig. 5 Stone microlith in the spinous process of the 12th thoracic vertebrate.

The trunk

The spinous processes of four sequential thoracic vertebrae (T5–T8) (**Fig. 4**) and the tenth thoracic vertebra exhibited porous raised lesions and ossified muscle tears in the areas of insertion of the muscles that extend and rotate the vertebral column. Transverse fractures on the four sequential vertebrae are typically the result of hyperextension and are usually associated with other injuries.[7] A small chalcedony stone flake pierced the left side of the spinous process of the twelfth thoracic vertebra (**Fig. 5**) and the bone healed around the puncture; unfortunately, the flake was too small to determine the type of weapon from which it had broken.[8]

Trauma due to tears of the shoulder muscles and ligaments that attach to the scapula were present on both scapulae. In addition, the body of the left scapula (**Fig. 6**) had been crushed, but healed in a network of interconnecting fracture lines and ossified soft tissue.

Two right ribs presented healed transverse fractures with raised calluses on their anterior surface. The first lesion measured 20.6 × 13.1 mm and the second measured 13.8 × 16 mm.

[7] Galloway in Galloway (ed.), *Broken Bones*, 102.
[8] Cook in Welsby, *Life on the Desert Edge*, 442–8.

Fig. 6 Crushed left scapular body with ossified muscle insertion tears.

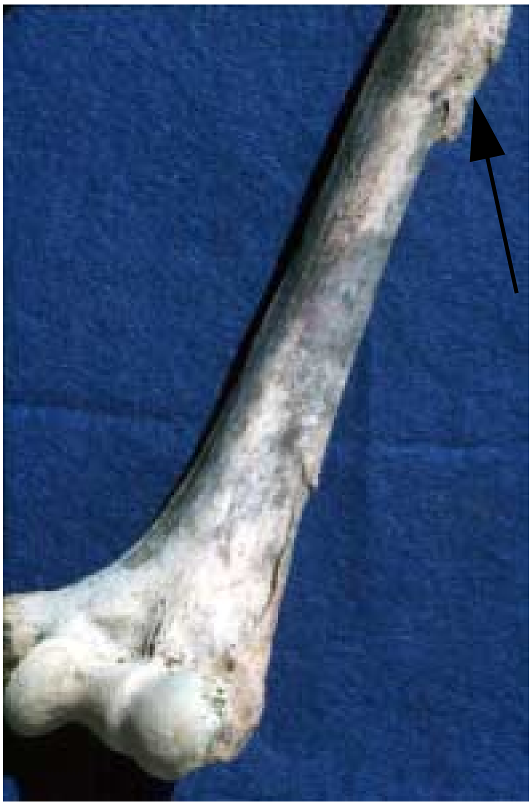

Fig. 7 Soft tissue trauma on left humeral shaft.

The arms

An area of disorganised bone growth measuring 34.1 × 10.5 mm was observed on the central shaft of the left humerus where muscles that extend and rotate the arm attach (**Fig.** 7). This lesion is typical of an injury sustained from a sudden, violent movement that tears the soft tissue from the bone.

Injuries to both forearms (described below) occurred when the arms were 'pronated' to some degree, that is, when the palm of the hand was turned downward and the forearm's outer bone (the radius) crossed over the inner bone (the ulna). These fractures are usually the result of an indirect force, such as a fall on an outstretched hand, where the force of impact is transmitted up the bone shaft to produce an oblique fracture line (> 45°) in relation to the long axis of the bone.[9] These types of injuries–rotational injuries–are easily identified by the gross deformity caused by opposing muscle exertion on the two fractured pieces and their subsequent non-union if not surgically treated (**Fig. 8**). Fractured bones do not always unite, resulting in unconnected, dense sclerosed bone ends. The causes of non-union are diverse, but because other pathological indicators were absent, non-union in this case was likely a result of movement of the two fragments during healing, excessive soft tissue between the fragments or the loss of alignment between the fragments.

9 Rogers, *Radiology of Skeletal Trauma*, 811–4.

Fig. 8 Paired rotational forearm fracture with non-union of the ulna and radius fractures (*in situ*).

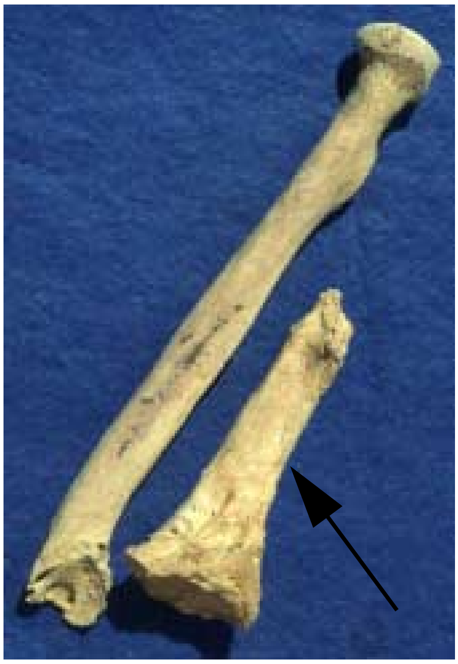

Fig. 9 Ununited left radial shaft rotational fracture and Smith's fracture (arrow).

The right forearm experienced a rotational fracture that involved both the ulna and radius (**Fig. 8**). The ulna fracture was 98 mm from the joint formed by the radius and wrist bones and 54 mm in length; the union of the fractured ends produced a 56° fracture line in relation to the longitudinal axis of the ulna. The degree of overlap of the ulna segments was 27 mm and when compared to the left ulna there was a 23 mm discrepancy in length, with the right ulna reduced to 250 mm. The 45mm long right radial lesion was 92mm from the radial edge of the wrist joint and produced a 60° fracture line. The distal segments of the ulna and radius were unaligned by 20° in relation to the longitudinal radial axis.

The left radial injury occurred when the arm was pronated so that the midpoint of the radius crossed directly over the ulna shaft when the injury occurred, although the ulna was unaffected. The lesion was located 75 mm from the distal radius surface and was 34 mm in length; the angle of the fracture line was 35° to the axis (**Fig. 9**) and the distal portion of bone was angled 20° in relation to the bone's axis. Both radii were similar in overlap (34 mm) and their lengths were reduced to 234 mm.

A Smith's fracture, also observed on the distal left radius (**Fig. 9**), occurs when one falls on the back of the hand, falls backward onto the hand or receives a blow to the back of the wrist resulting in the angulation of the distal radial fragment.[10] Both bone segments were in complete alignment to form a 28 mm long fracture line located 13 mm from the wrist joint resulting in an angle of 65° to the axis. Soft tissue trauma was present where the muscle involved with flexing the elbow inserts at the distal radius, while the distal surface of the radius that articulates with the wrist bones exhibited a network of fracture lines resulting from an impaction force.

[10] Rogers, *Radiology of Skeletal Trauma*, 847.

Fig. 10 Oblique fractures of the first metacarpal shafts.

Fig. 11 Transverse fracture of the third left metacarpal.

The legs

The lower leg injuries were minor—a small depression fracture occurred on the articular surface of the right distal tibia that forms part of the ankle joint. An incomplete transverse fracture, likely sustained from a direct force, was noted on the distal shaft of the right fibula.

The hands and feet

Eight injuries were observed on the hands. Four finger injuries were healed depressed lesions on the base of four phalanges (two from each side). The palms of the hands revealed four metacarpal fractures—the thumb on both hands (**Fig. 10**), the left middle finger (**Fig. 11**), and the little finger. Injuries to the thumb and little finger bones were oblique indicating that they were the result of an indirect force. The fracture of the third metacarpal was transverse and thus, the result of a direct force, either accidental or intentional.

Injuries to the feet were present on the left foot only and were also relatively minor. Three of the five lesions were depressed articular surfaces on the metatarsals and phalanges, typical results observed clinically of people stubbing their toes or tripping. Other lesions included soft tissue trauma on the base of the third metatarsal, and the absence of the tuft of the fifth distal phalanx.

Discussion

A major problem that bioarchaeologists encounter in the interpretation of a set of healed injuries is whether or not the injuries occurred during one incident, or whether they were the cumulative result of separate events. A series of actions producing trauma may be attributed to an individual's innate clumsiness, occupational risk, or penchant for assault (as the victim, assailant or both). In clinical practice, these 'injury recidivists' are typically young males and form a small percentage of the trauma sample.[11] Similarly, a portion of ancient people were also injury recidivists, a pattern identified by random multiple lesions at different stages of healing and a predisposition among males less than 35 years of age in two Kerma period skeletal samples.[12] While this individual suffered a range of lesions, there did not appear to be a major discrepancy in healing stages or isolated regions of repetitive insult to an area, which are characteristic patterns observed in abuse cases.[13] At best, bioarchaeologists can distinguish between unhealed injuries caused at the time of death, partially healed injuries that occurred shortly before death, and old well-healed lesions. The injuries of this male were in various locations and all of the lesions occurred well before the individual's death.

The second issue in palaeotrauma analysis is whether or not the injuries were accidental or intentional. As determined above, the injury pattern was inconsistent with that of continued abuse causing bone fracture, leaving a violent assault, a series of accidents, or some combination of the two as the ultimate cause of the injuries. Clinical cases show that injuries to the skull, particularly the facial region, are associated with interpersonal violence cross-culturally.[14] Most often, skull injuries occur as a depression injury on the cranium caused by a blunt object or a crush injury to the face, particularly the nasal or cheek bones due to a blow with a fist. However, it must also be considered that only about 30% of assault injuries to the face are manifest as fractures–abrasions, cuts, and haematomas make up the remainder.[15] Blunt trauma injuries were not unknown to the Kerma culture;[16] however, the injuries observed on this male were not typical of those received from striking the head on a flat surface or blunt trauma or from stoning, but are more typical of incomplete puncture wounds made with a small sharp object, or they may be the evidence of a non-specific infection.

The minor lesions, such as those to the vertebral column, joint surfaces, ribs and extremities, are ambiguous and may be attributed to either accidental or intentional actions and therefore on their own they do not indicate a specific injury mechanism. The extension fractures observed on the thoracic vertebrae are nearly always associated with other injuries when seen in clinical practice. Galloway,[17] for example, cites motor vehicular accidents and falls that result in the person being thrown against a fixed object after the impact as typical causes. Similarly, the scapular body fracture rarely occurs in isolation, and is most typically the result of a direct force.[18] This direct force may result from an intentional blow, but this may occur in a socially acceptable context, such as competitive sports, of which the Nubians were fond.[19]

[11] Poole *et al.*, *Surgery* 113 (1993), 608–11.

[12] Judd, *International Journal of Osteoarchaeology* 12 (2002), 89–106.

[13] Kerley, *Journal of Forensic Sciences* 23 (1978), 163–8; Walker *et al.*, *Journal of Forensic Sciences* 42 (1997), 196–207.

[14] Greene *et al.*, *Archives of Otolaryngology, Head, and Neck Surgery* 123 (1997), 923–8; Mwaniki *et al.*, *East African Medical Journal* 65 (1988), 759–63; Shepherd *et al.*, *Journal of the Royal Society of Medicine* 83 (1990), 75–8.

[15] Brismar and Tunér, *Acta Chirurgica Scandinavica* 148 (1982), 103–5; Chalmers *et al.*, *Australian Journal of Public Health* 19 (1995), 149–54; Matthew *et al.*, *Australian and New Zealand Surgery* 66 (1996), 659–63.

[16] Filer, *JEA* 78 (1992), 281–5; Judd in Welsby, *Life on the Desert Edge*, 458–543; Judd, *Sudan & Nubia* 5 (2001), 21–8.

[17] Galloway in Galloway (ed.), *Broken Bones*, 102.

[18] Galloway in Galloway (ed.), *Broken Bones*, 117–8; Haglund, in Galloway (ed.), *Broken Bones*, 297–300.

[19] Carroll, *Journal of Sport History* 15 (1988), 121–37; Filer, in Carman (ed.), *Material Harm: Archaeological Studies of War and Violence*, 47–74.

The ribs are often implicated in cases of abuse, but may also result from falls, accident, stress due to coughing or activity, or even birth.[20] The angle of the fracture line and location of the lesion aids in identifying the injury mechanism.[21] Transverse fracture lines are the result of localised blows to the chest or coughing, and may involve one or more ribs, such as the case presented here. Oblique fracture lines are caused by an indirect force, such as a fall, and are manifest on the back of the rib cage. Bilateral oblique rib fractures are associated with an episode of crushing.

The high number of hand and foot injuries is not unreasonable when compared to modern clinical research, which identifies the bones of the hand as the most frequently traumatised, although many are overlooked in a radiological assessment or not even noticed by the individual. A survey of hand and foot injury mechanisms in developing countries reveals mechanisms that were also present in ancient Nubia: sports, agriculture, falls, blunt trauma, burns, household accident, animal and human bites, and fights.[22] Some hand injuries are associated with fighting, such as the boxer's fracture where the metacarpal head is bent towards the palm; a shearing of the base of the first metacarpal from a misplaced punch; a sideways blow with the side of the hand; tooth-punch injuries received when the fist contacts the tooth; twisting injuries and bites resulting in amputation.[23] The injuries to the palm bones of this male, particularly those of the first metacarpal, may indeed have been due to a scuffle, but social sports or striking a blow against an inanimate object cannot be ignored.[24]

The people from this region were identified as members of the Kerma culture, a society closely connected to a reliance and reverence for cattle. The abundance of bovid bones and effigies retrieved from domestic refuse and ritual contexts at Kerma and the neighbouring village of Gism el-Arba,[25] in addition to the faunal remains from the Kerma Moyen burials at P37,[26] confirm the importance of animals to this culture. The close proximity and interaction with pastoral animals does pose an injury hazard, particularly in the dairy and beef industry.[27] Busch[28] lists the fracture-related trauma sustained by a 57 year old farmer who was repeatedly knocked down by a 2,000 pound (about 909 kg) bull: 13 rib fractures, three forearm fractures, bilateral scapular fractures and dental fractures–a similar assortment of injuries displayed by this Kerma male.

Falls from heights, such as ladders or roofs, may also have been common during the Kerma period, and like the present day, they were likely due to the carelessness of those on the ladder.[29] Falls are due

[20] De Maeseneer *et al.*, *American Journal of Emergency Medicine* 18 (2000), 194–7; Galloway in Galloway (ed.), *Broken Bones,* 107; Walker *et al.*, *Journal of Forensic Sciences* 42 (1997), 196–207.

[21] Galloway in Galloway (ed.), *Broken Bones,* 107.

[22] Ip *et al.*, *Injury* 27 (1996), 279–85; Jonge *et al.*, *Journal of Hand Surgery (British and European Volume)* 19B (1994), 168–70; Kelly *et al.*, *Injury* 27 (1996), 481–4; Loro and Franceschi, *East African Medical Journal* 69 (1992), 697–9; Mock *et al.*, *American Journal of Public Health* 85 (1995), 927–31; Smith and Barss, *Epidemiology Revue* 13 (1991), 228–66.

[23] Adams and Hamblen, *Outline of Fractures Including Joint Injuries*, 171; Rogers, *Radiology of Skeletal Trauma*, 945–81.

[24] Hershkovitz *et al.*, *International Journal of Osteoarchaeology* 6 (1996), 167–78.

[25] Bonnet and Ferrero, *Sahara* 8 (1996), 61–6; Chaix, *Sahara* 1 (1988), 77–84; Chaix and Grant, in Krzyzaniak *et al.* (eds) *Environmental Change and Human Culture in the Nile Basin and Northern Africa until the Second Millennium BC*, 399–404; Gratien, *Sudan and Nubia* 3 (1999), 10–12.

[26] Grant in Welsby, *Life on the Desert Edge,* 544–55.

[27] Boyle *et al.*, *Epidemiology* 8 (1997), 37–41; Busch *et al.*, *Journal of Trauma* 26 (1986), 559–60; McCurdy and Carroll, *American Journal of Industrial Medicine* 38 (2000), 463–80.

[28] Busch *et al.*, *Journal of Trauma* 26 (1986), 559–60.

[29] Muir and Kanwar, *Injury* 24 (1993), 485–87.

to the ladder base being too close to the wall, poorly tied off ladders and being accidentally knocked off the ladder by a third party. A fall may also have been the result of collecting dates from a date palm, an indigenous tree to this area, which no doubt supplemented the diet among the ancients. Falls from coconut palms are well recorded among tropical clinicians and the most common injuries include forearm or vertebral fractures.[30] In falls from a height greater than standing height, the lower limb is most frequently injured, while short falls off a stepladder account for upper limb fractures, specifically the distal radius.

The injuries to the forearm are the most diagnostic in this case and, as discussed above, the indirect force injuries (Smith's and rotational fractures) are associated with a fall on an outstretched hand. Another type of forearm injury, the parry fracture, is associated with interpersonal violence. This injury occurs on the distal third of the ulna, is transverse, involves minimal displacement in any direction, rarely involves the neighbouring radius and is nearly always the result of raising the arm in front of the face to fend off a blow.[31] This individual may have fallen forward and extended both forearms to break his fall, which would explain the similarity of fracture position and healing stage on the bones. The presence of the Smith's fracture, also well healed, indicates an additional fall, which may or may not have occurred at some point during the event in which the rotational forearm injuries were sustained. These forearm injuries are indeed typical of falls and when observed among ancient skeletal material, they are most often attributed to environmental or intrinsic factors[32] rather than suspect that the injuries were sustained from a fall during a physical confrontation, a common phenomenon in clinical observations of injury patterns.[33]

Conclusions

Multiple injuries occurring during a single incident or accumulated over time are not unusual in modern clinical practice and similarly were not unknown among ancient people. A young male adult from the Kerma Ancien Period in the Kawa vicinity exhibited a remarkable collection of injuries, none of which occurred at the time of death. No fractures were specifically associated with interpersonal violence that is, blunt force skull injuries, facial fractures or parry fractures. The presence of a Smith's fracture and rotational radial fracture on the left radial shaft suggests that at least two separate falls occurred, which permitted his radius to fracture in opposing directions. The injuries to the spine and scapulae are suggestive of at least one particularly high-impact incident. The proximate aetiologies of his injuries were likely falls, however, this man was no stranger to violence, as indicated by the embedded lithic fragment in one of his vertebrae, which had occurred before death. Whether or not the ultimate cause of his injuries involved a human antagonist in each incident remains a mystery as does the cause of death–perhaps this young man just experienced one accident too many.

30 Barss *et al.*, *British Medical Journal (Clinical Research Ed.)* 289 (1984), 1717–20; Mulford *et al.*, *Australian and New Zealand Journal of Surgery* 71 (2000), 32–4.

31 Richards and Corley in Rockwood *et al.* (eds) *Rockwood and Green's Fractures in Adults*, 869–928.

32 Judd and Roberts, *American Journal of Physical Anthropology* 105 (1998), 43–55; Judd and Roberts, *American Journal of Physical Anthropology* 109 (1999), 229–43; Kilgore *et al.*, *International Journal of Osteoarchaeology* 7 (1997), 103–14.

33 De Souza, *East African Medical Journal* 45 (1968), 523–31.

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