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Case Report

Cranial trauma and the assessment of posttraumatic survival time

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ABSTRACT

Assessment of trauma on skeletal remains can be very difficult, especially when it comes to the estimation of posttraumatic survival time in partially healed lesions. The ability to reliably estimate the time an individual has survived after sustaining an injury is especially important in cases of child abuse and torture, but can also aid in determining the association between an injury and eventual death. Here a case from South Africa is reported, where the skeletal remains of an unknown individual were found with cranial and scapular fractures. These fractures all presented with macroscopic features indicative of healing. Using recently published data on the timing of fractures by De Boer et al., the two sets of cranial trauma and the scapular fracture were assessed by means of radiology, histology and microCT scanning. This was primarily done in order to obtain more information on the events surrounding the death of this individual, but also to assess the usability of the published methods on cranial fractures. It was found that the initial trauma was most likely sustained at least two weeks before death, whilst a neurosurgical procedure was performed at least one week before death. It seems that cranial fractures, especially if stable, may show some different healing features than postcranial fractures. The individual has since been identified, but unfortunately as is often the case in South Africa, limited information is available and the medical records could not be found.

1. Introduction

Trauma observed on skeletal remains can provide significant information on the circumstances surrounding death, and also the past experiences of an individual. However, the assessment of trauma in the absence of soft tissue is often problematic [1,2]. It is especially difficult to determine whether an individual had survived a traumatic event for some time after the injury occurred, and if so, for how long. This is particularly relevant in cases of child abuse which may be characterized by chronic, patterned abuse [3,4], or human rights abuses [5]. In these cases, the investigator would look for injuries in different phases of healing. These signs of healing can be very difficult to assess, especially in dry bone.

According to the majority of literature describing trauma as observed in a forensic anthropological context, fractures can be classified as having occurred 'antemortem' (before death), 'perimortem' (occurring around the time of death) or 'postmortem' (after death). Macroscopically, antemortem lesions are characterized by the presence of healing features such as callus formation, whereas postmortem lesions are identified by the lack of these features. Perimortem lesions are often difficult to identify, but are usually identified by a green bone response, which occurs when the bone is still elastic, i.e. fresh bone [6–9]. The problem with assessing these lesions is that they are not unequivocally ante- or postmortem, as they may exhibit a green-bone response for as long as there are substantial amounts of collagen preserved in the bone.

As De Boer et al. [10] pointed out, simply describing lesions as having occurred either antemortem, perimortem or postmortem has severe limitations as it gives no estimation of the length of the time period between the moment of injury and the time of death (the posttraumatic survival time). In an attempt to make a gross estimation of the posttraumatic survival time, some investigators describe antemortem fractures as either being 'healed' or 'healing', with healed lesion suggesting a longer posttraumatic survival time than those which are still in the process of healing.

A further refinement of the estimation of the posttraumatic survival time beyond simply describing a lesion as being 'healed' or

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'healing', is thus desirable. This refinement is possible as, after fracturing, bone tissue response follows a strict time-dependent developmental sequence. This developmental sequence of events is fixed, irrespective of variables such as the type of lesion, its location, the age at death and health status of the individual [11–14]. It should however be kept in mind that the rate at which this sequence progress may vary, especially in children where bone heals much faster. The location of the lesion and other factors may also contribute toward variations in the tempo of healing [15]. Also, the consecutive phases of healing gradually blend into one another and a single lesion may thus show features of several healing phases at once [16]. It is therefore advisable to work with minimum amounts of elapsed time rather than attempting to estimate the maximum amount of elapsed time.

Several papers addressed either the radiological [17–20] or histological [21,22] dating of fractures. Following a review of the literature, Maat [15] constructed a time table that linked the elapsed time after bone tissue injury to radiographic and histological healing features. In this publication, Maat outlined features seen with traditional (fresh tissue) histological sections, but then also pointed out which of these features can be seen on a dry bone specimen. This method was said to also be usable for both adult and pediatric individuals [23]. Since the sequence after amputation and fractures are much alike, the approach should be usable for the timing of amputations too. For example, Mays [24] applied Barber's gross anatomical approach in a case study regarding healed amputations. Cattaneo et al. [25] also found useful histological markers for the dating of traumatic lesions in macerated bone.

In order to test the consistency in the detectability of healing features as listed by Maat [15] and described by Barber [26–28] in dry bone material, De Boer et al. [10] evaluated these features in order to determine to what extent they allow for estimation of the 'age' of an injury. Using a variety of bone samples, they assessed the healing features using unstained and stained dry bone histology and traditional radiography. These authors found that a considerable amount of healing features could still be reliably detected in dry bone tissue, and they related the visible healing features to the possible time interval in which they could appear. Only postcranial remains were assessed in this study.

After the discovery of the severely decomposed remains of an individual with partly healed fractures of the skull and scapula in South Africa, the opportunity arose to test the methods described by De Boer et al. [10] on cranial fractures which were most likely of two different ages. Based on the macroscopically visible traumatic changes in the deceased individual, it seemed probable that this person experienced a serious traumatic event for which he received surgical treatment. The deceased survived the injury and surgery for some time, as suggested by the macroscopically visible evidence of healing, after which he died. The aim of this study was to assess whether the recently proposed dating method of De Boer et al. [10] can be applied to cranial remains, and thus support our assumptions regarding these traumata. In addition to the methods described by De Boer et al. [10], micro-Computed Tomography (micro-CT) scanning was also employed to assess its usability in this context.

2. Case description

In 2009, the severely decomposed remains of an adult were found in a deserted field in South Africa. The remains were completely skeletonized and comprised of a skull without mandible, both scapulae, humeri and femora, the right os coxa and right tibia. Chew marks from large carnivores were evident, which caused considerable damage especially to the postcranial skeleton.

Estimation of the age at death of the individual was severely complicated due to the fragmentary condition of the remains. All permanent dentition had erupted and all long bone epiphyses were fused and obliterated. The cranial sutures showed some closure, and the synchondrosis spheno-occipitalis was obliterated. The pubic symphysis was in a phase 5 or 6 [29], and some lipping at joints was evident. As a result, the individual was estimated to have most probably been between 30 and 60 years of age at the time of death [9].

The skull was robust in appearance, with large mastoid processes, a prominent glabella and sloping forehead. The pubis was triangular in shape, with a narrow subpubic angle. Postcranial measurements fell into the male range [9]. The remains were therefore diagnosed as most likely being that of a male. Morphological characteristics of the skull indicated an individual of African descent, and the stature, estimated with the combined lengths of the femur and tibia, yielded an estimate of 158.4 ± 2.371 cm [30,31].

Extensive recent, partially healed antemortem trauma was evident on the skull. A linear fracture was present on the left side of the skull that stretched from the roof of the left orbit, through the frontal and parietal bones and ending about 4.5 cm above the left asterion (Fig. 1). Its edges were rounded off, indicating that some healing had taken place and that the individual had lived for some time after sustaining this fracture.

On the right side of the skull were several drill (Burr) holes, where a large flap of the skull had been surgically removed, most probably to treat an intracranial bleeding (Fig. 2). This loose segment of bone was about 9.5 cm high and 15 cm long. Two smaller drill holes were present on the loose flap of bone. Both these holes were in the parietal bone and had been drilled through the outer table only. The anterior one of these two holes still had blue nylon suturing material through it. The purpose of this suturing is not clear, but may have been used to assist in manipulating the bone flap or attaching the dura to the bone.

The right scapula showed a fracture of the supraspinatus and infraspinatus areas and the spine itself (Fig. 3). This fracture also showed some macroscopic signs of healing with new bone formation. The grayish discolouration around the fracture edges visible on the photograph are new, woven bone deposits.

From the macroscopically observed traumatic changes, it could be deducted that this person had undergone major trauma of the skull (and scapula) for which he received invasive surgery. He had survived the injury and surgery for some time as there is evidence of initial healing, after which he died from unknown causes.

Fig. 1. Antemortem fracture on left side of the skull, showing macroscopic signs of healing (lesion 1).