Antunes-Ferreira Nathalie (Orcid ID: 0000-0002-0146-6369)

Curate Francisco (Orcid ID: 0000-0002-0480-209X)

Interpreting injury recidivism in a rural post-medieval male individual from Bucelas, Portugal

Injury recidivism in a rural post-medieval individual from Portugal

Nathalie Antunes-Ferreira[1,2,3], Carlos Prates[4], Francisco Curate[5,6,7]

[1] Centro de Investigação Interdisciplinar Egas Moniz, Instituto Universitário Egas Moniz, Monte da Caparica, Portugal

[2] Laboratório de Ciências Forenses e Psicológicas Egas Moniz, Egas Moniz Cooperativa de Ensino Superior, Monte da Caparica, Portugal

[3] Laboratory of Biological Anthropology and Human Osteology, CRIA/FCSH, Universidade Nova de Lisboa, Lisboa, Portugal

[4] IMI art, Imagens Médicas Integradas / Affidea, Lisboa, Portugal

[5] Research Centre for Anthropology and Health, Department of Life Sciences, University of Coimbra, Coimbra, Portugal

[6] Laboratory of Forensic Anthropology, Department of Life Sciences, University of Coimbra, Coimbra, Portugal

[7] School of Technology of Tomar, Polytechnic Institute of Tomar, Tomar / Mação, Portugal

Corresponding author: Nathalie Antunes-Ferreira

Address: Instituto Universitário Egas Moniz, Campus Universitário Quinta da Granja, Monte de Caparica, 2829-511 Caparica, Portugal

Telephone number: (+351) 212 946 700

E-mail address: naferreira@egasmoniz.edu.pt

Abstract

Injury recidivism studies assess the lived experience of individuals who endure multiple traumatic incidents, conveying a nuanced contextualization of individual suffering within a reticulate of social and cultural processes. During a recent archeological excavation, a skeleton of a middle-aged male dating to the 17th – 18th centuries AD was excavated in the churchyard of the Chapel of the Holy Spirit in Bucelas (Portugal). This individual exhibited a mixture of healed and healing fractures, that prompted poor functional long-term outcomes, and an increase in the risk of death. Macroscopic and medical imaging (computerized tomography) analyses revealed lesions in the right shoulder, right and left ribs, 5th right proximal phalanx and right distal femur. Fracture complications include myositis ossificans and chronic osteomyelitis. The results are interpreted in the broader sociocultural circumstances of Bucelas during the early modern period, in order to investigate the causes of this individual's accumulated trauma and the possibility of health-related care associated with it.

Keywords

Introduction

Skeletal trauma is a pervasive find in human remains from different archeological contexts, with fractures being the most common type of trauma observed in historical assemblages (Ortner, 2003; Redfern & Roberts, 2019). The anatomical and sociocultural implications of trauma in the past are complex and multidimensional; as such, the theoretical landscapes, research questions and methodological systems used to investigate skeletal injuries are diverse (Gilmour et al., 2019; Lovell, 1997; Redfern & Roberts, 2019). Paleopathological studies of skeletal injury have made important contributions to the interpretation of biocultural contexts in the past, addressing issues such as interpersonal violence (Erdal & Erdal, 2012; Fernández-Crespo, 2017; Pfeiffer, 2016; Piombino-Mascali et al., 2006), age and gender (Curate et al., 2010; de la Cova, 2012; Ives et al., 2017; Robbins et al., 2012), social inequality and structural violence (Antunes-Ferreira, 2015; de la Cova, 2017, 2012, 2010; Fernandes et al., 2017; Osterholtz, 2012), subsistence strategies (Domett & Tayles, 2006; Lambert & Welker, 2017), territorial organization (Collier & Primeau, 2019; Šlaus et al., 2012), child abuse (Gaither, 2012; Wheeler et al., 2013), surgical procedures or medical assistance (Binder et al., 2016; Giuffra & Fornaciari, 2017), and the provision of care (Dequeker et al., 1997; Lovell, 2016), among others.

After decades of population-focused approaches – valuing above all models that addressed wider evolutionary and epidemiological questions – research agendas in paleopathology became again more heterogeneous, with an ongoing rehabilitation of richly contextualized, theory-governed, studies of individuals (Grauer & Buikstra, 2019). Case studies, which focus

on certain skeletal lesions or diagnostic topics, and osteobiographies, emphasize a plethora of individualizing features, systematically intertwined in the biological, social, cultural and political aspects of an individual's life (Grauer & Buikstra, 2019; Robb, 2002; Stodder & Palkovich, 2012), being paramount in the current redefinition of the paleopathological ethos. As noted by Paul Farmer (2003), the experience of suffering is not suitably revealed by statistics, and to explain it one should embed individual biographies within their cultural, social, political or economic contexts. More nuanced theoretical frameworks for the study of individual experiences of health and disease comprise the bioarcheology of care, life course perspectives, and the bioarcheology of personhood (including fictive narratives) (Boutin, 2016; Glencross, 2011; Tilley, 2015b; Watkins & Muller, 2015).

In this work, we evaluated the functional and social consequences of several skeletal injuries suffered by a male individual from the Chapel of the Holy Spirit in Bucelas (Lisbon, Portugal). The interpretative challenges posed by the combination of different types of trauma and its likely functional impacts – at the individual and societal levels – were addressed through the perspectives of injury recidivism as defined in bioarcheology (Judd, 2002, 2017; Mant, 2019) and the bioarcheology of care (Tilley, 2015b; Tilley & Oxenham, 2011; Tilley & Schrenk, 2017).

Materials and Methods

The Chapel of the Holy Spirit (Figure 1) was located in the rural village of Bucelas, in the environs of Lisbon (Portugal). It was built during the 14th century and destroyed in the early 20th century AD (Fernandes, 2013). The associated churchyard was probably used between the 15th and the 19th centuries. During a recent archeological excavation, 157 primary inhumations comprising 98 adults (59 males, 33 females and 6 of unknown sex) and 59 non-adults, were exhumed (Table 1). Individuals were shrouded and placed directly in the grave soil, in supine position with the head facing west and the feet facing east. The prevalence of fractures in the overall adult sample is 18.4% (18/98).

The focus of this study is the skeleton of individual #15, which stands out from the remaining sample as it shows evidence of multiple injuries with major sequelae. This inhumation is probably from the 17th – 18th centuries, as suggested by archeological data, including the presence of blue-on-white Portuguese faience that was produced during this chronological period (Casimiro and Sequeira, 2017; Estêvão & Antunes-Ferreira, 2020). The skeleton was complete and well preserved (Figure 2). Sex was estimated from the morphological features of the skull and pelvis (Bruzek, 2002; Buikstra & Ubelaker, 1994), indicating a male individual. Age-at-death assessment suggests the individual was older than 40 years of age: the analysis of the sternal end of the 4th rib points to an age interval of 43 – 55 years old (İşcan et al., 1984), the pubic symphysis to an age interval of 23 – 57 years old (Brooks & Suchey, 1990) and the auricular surface metamorphosis to an age above 50 years old (Lovejoy et al., 1985). The physiological length of the left femur (428 mm) indicates an approximate stature of 161 cm (Mendonça, 2000).

Computerized tomography (CT) scan analysis of the right femur (80 kV, 250 mA, slices 0.6/0.3 mm, 1315 images) and the right scapula (80 kV, 250 mA, slices 0.6/0.3 mm, 537 images) was performed with a Siemens Somatom Definition AS 128. Digital radiography analysis of the right femur (60 kV, 56.0 mA) and the left second metacarpal (60 kV,20.0 mA) was implemented with Siemens Iconos R200 equipment and Kodak DirectView CR850 film. The cortical index (MCI) at the second metacarpal midpoint was estimated according to Ives and Brickley (2004) and the Z-Score (describes a value's association with the mean of a group of values, being measured in terms of standard deviations from the mean) was calculated comparing the obtained value with the sample means for late 19th – early 20th centuries older males provided by Curate et al. (2019). The paleopathological analysis followed the recommendations detailed in standard textbooks (Buikstra & Ubelaker, 1994; Buikstra, 2019; Ortner, 2003).

Results

The male individual under study had evidence of multiple trauma (Figure 3). Macroscopic analysis revealed the presence of new bone formation in the right acromial process, while CT data analysis exposed three distinct areas of superficial layers of bone deposition overlaying the normal cortical bone, at partial insertion areas of the main rotator cuff muscles (Figure 4). The new bone was more evident on the bed of the *supraspinatus* muscle, but it is also observed at the insertion of the *infraspinatus* and *subscapularis* muscles. Both the right acromion and proximal humerus (in the articular surface and in the greater tubercle) display evidence of eburnation. Fractures were identified in six ribs (9th and 10th right, and 9th, 10th, 11th, and 12th left) by the presence of a callus located in the middle (left ribs) to the sternal (right ribs) portion of the shaft (Figure 5). Fractures were well-healed, except for an ununited fracture in the 11th left rib (this rib also exhibited a well-remodeled fracture, located *c.* 20 mm to the sternal side). The unfused rib fracture presented with woven bone, showing active remodeling (Figure 6). Right 5th proximal hand phalanx presents extensive new bone formation with thickness and deformation in the dorsal middle diaphysis. The right femur displays two striking traumatic lesions: a bone growth consistent with traumatic myositis ossificans (MO) is noticeable on the lateral proximal diaphysis, and its distal diaphysis exhibits an extra-articular, supracondylar, displaced comminuted fracture accompanied by deformity and shortening of the diaphysis (Figure 7; Table 2). An extensive callus and MO were identified around the injured area. The CT axial images additionally show radiographic signs of chronic osteomyelitis, revealing abundant sclerotic bone near the fractured cortex, along both the endosteal and periosteal surfaces. In at least three levels, there are clear evidence of three cloacae (Figure 8). A thinner, more irregular, and less dense arch of the intramedullary displaced cortex represents a partial sequestrum. Secondary alterations include the shortening of the femur (maximum length difference of 22 mm between sides, resulting in dysmetria of the inferior limbs), and severe osteoarthritis of the right knee. The MCI was 41.1 (Z-Scores between −0.885 [age class 50 – 59 years old] and –0.450 [age class 80+ years old]), probably lower for age.

Discussion

The male individual from Bucelas shows evidence of multiple injuries, with a combination of healed and healing trauma, and while some of the observed fractures could have resulted from a single event – particularly those that were well-healed – other injuries were certainly experienced in separate incidents. The 11th left rib showed two fractures in different locations, one well-remodeled and other still healing. Other ribs exhibited well-healed fractures. A severe fracture of the distal right femur showed extensive remodeling, while injuries in a right proximal hand phalanx and right acromial process were also well-remodeled. Also, the few existing epidemiological studies suggest that in a traumatic event that produces multiple fractures, certain skeletal regions tend to be more affected concurrently, for example, fractures of the shoulder girdle are commonly associated with thoracic fractures, including spinal fractures; and finger fractures are associated with fractures of the metacarpals and the distal forearm (Feichtinger et al., 2019). The fractures that affected this individual do not correspond to any of the commonly observed multifracture patterns.

As such, the categorization of this individual as an *injury recidivist* is plausible (Mant, 2019). The use of the term is sometimes equivocal, with different operational definitions in clinical and bioarcheological research (Judd, 2017; Redfern et al., 2017), but it is a powerful concept that offers a nuanced understanding of the intricate relationships between trauma, individual experiences and social contexts (de la Cova, 2017; Grauer & Buikstra, 2019; Redfern et al., 2017). This case also highlights the excellent resolution and 3D multiplanar diagnostic capacities of CT when compared with the 2D data of traditional radiography.

The lesions in the shoulder girdle area, particularly those in the right acromial process, were probably produced by an exogenous cause, such as trauma or infection. In both cases, inflammation, a vascular response to traumatic or infectious tissue damage, acted as a stimulus to a healing and repair process that may include an osteoblastic reaction, leading to new bone apposition at partial insertion regions of the main three rotator cuff muscles. These findings suggest a musculotendinous trauma of the shoulder as the very probable cause. Shoulder injuries are common in both young and aging population, and shoulder pain is a frequent associated problem, responsible for lengthy periods of disability, loss of productivity, work absenteeism and inability to accomplish domestic activities (Linsell et al., 2006).

Rib fractures are common and often result from accidents, falls, or direct blows to the chest (Brickley, 2006; Galloway & Wedel, 2014). Fractures in the ribs were in different stages of recovery, with at least one fracture on the left side still in the process of healing. Complications related to rib fracture include pain, hemothorax, pneumothorax, pulmonary contusion, among others. Fractures of the 9th, 10th, and 11th ribs, commonly caused by rotational types of injury, are associated with intra-abdominal injury, particularly liver (right ribs) and spleen (left ribs) injuries (Galloway & Wedel, 2014; Talbot et al., 2017). In fact, lower rib injury has long been regarded as a marker for internal organ damage (Talbot et al., 2017).

Fractures of the phalanges – and particularly those in the proximal phalanx of the 5th digit – are

among the most common of the upper extremity. Their incidence is greater in males, with a peak between 10 – 40 years old, and can be produced by road traffic accidents, falling objects, assault, falls, and even trivial activities, such as jar opening (Singh et al., 2011). Phalangeal fractures are also relatively common in archeological contexts, and fractures of the hand are frequently associated with other injuries (Kilgore et al., 1997; Mant, 2019; Redfern, 2010).

Fractures of the distal femur are very infrequent and severe, associated with high morbidity and mortality, and occur normally either as high-energy trauma in younger men or low-energy injuries in older women with osteoporosis (Streubel et al., 2011). The recorded fracture is extra-articular and consistent with an open wound. The femoral fracture is consistent with high-impact trauma (Villa et al., 2013), displaying bone impaction, secondary inferior member dysmetria and osteoarthrosis (OA) of the knee, development of exogenous osteomyelitis and myositis ossificans. Its combination with other traumatic lesions – although it is improbable that all fractures occurred in the same event – also suggests a high-impact traumatic hazard.

Lesions in the femoral diaphysis include two occurrences of myositis ossificans, probably posttraumatic. MO is a syndrome characterized by a non-neoplastic heterotopic ossification (i.e., calcification) in an area that has been exposed to trauma. Symptoms include pain, local tenderness and stiffness, and functional compromise of the affected leg (Buselli et al., 2010). Also, the presence of cloacae and *sequestrum* are suggestive of exogenous posttraumatic osteomyelitis. Posttraumatic osteomyelitis is a common complication of open fractures, and it is frequently caused by *Staphylococcus aureus* (polymicrobial infections are also common) (Sheehy et al., 2010). Individuals with chronic osteomyelitis endure pain and disability, and persistent discharges of putrid pus. Long-term failure of medical management can cause mobility deficits, prolonged support, depression, unemployment, and death (Huang et al., 2016). Infected fractures and osteomyelitis in adults have been infrequently described in the paleopathological literature (Flensborg et al., 2013; Judd & Roberts, 1999; Ortner, 2003; Wood-Jones, 1910), a likely reflection of both the low prevalence of open fractures and associated high mortality (Redfern & Roberts, 2019).

The aforesaid multifracture scenario undoubtedly prompted poor functional long-term outcomes for this individual, with a prolonged period of recovery, with probable immobilization and bed rest, and an increase in the risk of death. OA observed in the knee suggests that the limb was used after the fracture, and locomotion after fracture could have been aided by some type of crutch – but it was not found any evidence of its usage. Some occupational activities could have been performed by this individual, including basketry, but most agricultural works would have been unfeasible.

Cortical bone mass measured at the second metacarpal was possibly low for age, as suggested by the documented Z-Scores, and, although some fractures (i.e., osteoporotic fractures; Curate, 2014) are linked to low bone mass, the recorded osteopenia most likely stemmed from decreased mechanical loading: there is a possibility that bone loss occurred after fracture and not before (Brickley & Ives, 2008). In fact, fractures and other injuries often compromise the functional capability of individuals, affecting their independence in walking, obtaining food,

and maintaining personal hygiene. In the case of a significant impact on individual functional capacity, the provision of care (healthcare or other) by third parties is essential for survival (Tilley, 2015a; Tilley & Oxenham, 2011).

Documentary sources refer to the existence of the Hospital of the Holy Spirit in Bucelas, as well as the Confraternity of the Holy Spirit, in its environs during this chronological period, which gave material and health support to the pilgrims, poor, sick and dying people (Fernandes, 2013; Villaverde, 2018) – but community support networks most probably involved relatives, and possibly town physicians or even barber-surgeons (António & Curate, 2019). The Hospital of the Holy Spirit provided food, rest, and minor treatments to its patients (Fernandes, 2013; Villaverde, 2018). Family care toward the frail, the elder or the infirm is still a normative behavior of great social and cultural relevance in contemporary societies (Toseland et al., 2001). In the southern European Catholic societies, arranged around heterogeneous family structures (between the nuclear, stem and / or extended families), solidarity and care toward the vulnerable was typically the responsibility of the families, and within these, of female family members (Leandro, 2006; Reher, 1998).

The etiology of the observed injuries is probably multifactorial, reflecting a combination of individual agency and socially defined circumstances. For example, middle-aged men generally experience multiple injuries more frequently than women (Redfern et al., 2017). Additionally, historical records suggest that most of the inhabitants of Bucelas during the early modern period were rural workers, with some references to skilled craft workers, particularly coopers, basket makers, bricklayers, blacksmiths and fur beaters (Villaverde, 2018). It is therefore conceivable that some, if not all, of the described injuries resulted from work-related accidents. Bucelas is an ancient wine-region, since at least the Roman colonization of the Iberian Peninsula. After the Peninsular War (1807–1814), Lisbon «Hock» (white wine) became an important export to England (Robinson, 2006). Farming has always been among the most hazardous occupations (Judd & Roberts, 1999). Occupational health risks of winery laborers comprise both specific hazards, such as exposure to carbon dioxide in confined spaces, and the same injuries faced by agriculture workers in general, including skeletal injuries caused by falls or farm accidents (Anaya-Aguilar et al., 2018). Moreover, the severity of recorded lesions prompted an extended period of recovery, with probable social sequelae, such as unemployment and impoverishment.

Substance abuse has been consistently linked with injury recidivism, both in rural and urban populations. Alcohol consumption, in particular, is associated with a higher risk of trauma and injury recidivism in modern populations (Cordovilla-Guardia et al., 2017; Nunn et al., 2016; Toschlog et al., 2007). It is not possible to reconstruct this individual's experience with substance abuse, but in the larger social context of 17th – 18th centuries Bucelas it is plausible to connect injury recidivism with prevalent alcohol consumption and abuse. In Portugal, during the 18th century, the consumption of alcohol (especially wine and brandy) increased, with a growing perception of alcoholism as a social problem. Government policies, church homilies and newspaper headlines tried to oppose a thriving *collective disease*, then accountable for impoverishment, interpersonal and domestic violence, crime, suicide, incest, prostitution and

all sorts of physical injuries (Vaquinhas, 1995; Silva, 2007). The association of injury recidivism and alcoholism is further diffracted by poverty (the location of this individual's grave, outside the religious building, and the modesty of the burial, point to an underprivileged socioeconomic background), producing a *pathogenic social spiral* in the larger landscape of structural violence (Herrick & Reubi, 2017).

The type, severity and pattern of injuries observed delimit and clarify to a point the corporeal experiences of this male within the biological and social processes of Bucelas. The latter are especially meaningful to integrate individual accumulated trauma in the social fabric, contextualizing different but integrated loci of community life, such as work and related accidents, societal relief, addictive behavior, interpersonal and structural violence.

Final remarks

Injury recidivism is a major subject of research in paleopathology and bioarcheology, and the study of trauma circumstances in which a combination of antemortem healed, healing, or perimortem elements is present conveys a compelling assessment of the lived experiences of individuals that suffer multiple traumatic incidents (Mant, 2019; Redfern et al., 2017). A male individual from Bucelas accumulated multiple injuries in at least two incidents. The observed skeletal trauma – including injuries in the right shoulder, several ribs, right hand 5th proximal phalanx and right distal femur, with traumatic myositis ossificans and osteomyelitis – undeniably prompted a long-term functional incapacity, probably framed by charity or family support but also by work-related accidents, dependency behavior and structural violence, and an increased risk of death.

Acknowledgments

Data availability statement

The data that support the findings of this study are available from the corresponding author, [NAF], upon reasonable request.

Conflict of interests

The authors declare no conflict of interest.

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Table 1. Sex and age-at-death distribution of the individuals from the Chapel of the Holy Spirit (adult age categories adapted from Buikstra & Ubelaker, 1994).

Age categories	Females	Males	Unknown sex	Total
Non-adults	-	-	59	59
Young adults	4	14	1	19
Middle adults	17	29	1	47
Old adults	8	7	0	15
Indeterminate adults	4	9	4	17

Table 2. Description of the fracture of the right distal femur after the *Fracture Recording Method* depicted in Redfern & Roberts (2019).

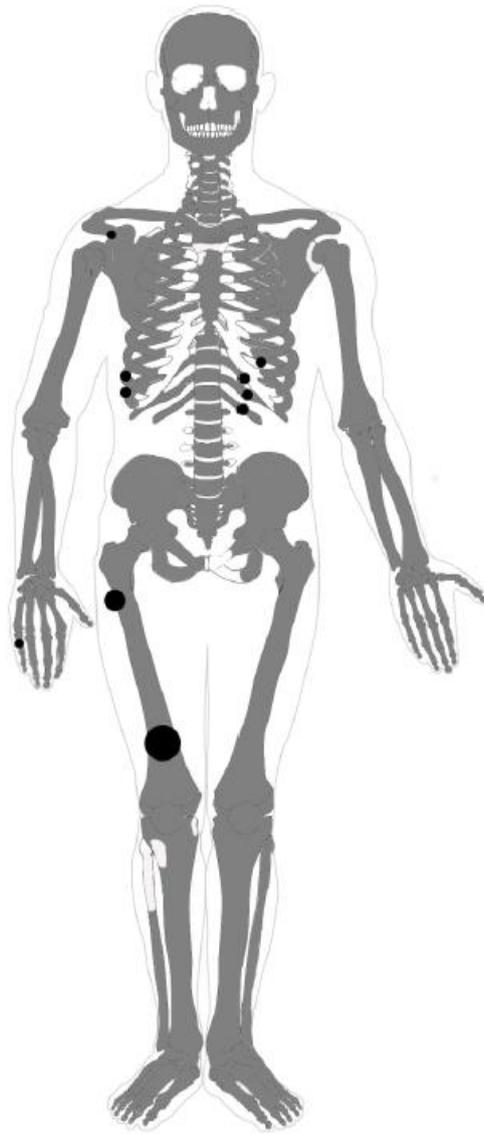| Sex and age	Male, +40 years old
Bone and affected segment	Right distal femur
Fracture position	Distal, supracondylar
Type	Comminuted fracture (with at least three discontinued fragments of cortical bone)
State of healing	Healed fracture, extensive callus of lamellar bone
Infection	Osteomyelitis: three cloacae and a partial sequestrum
Underlying pathology	No
Joint degeneration	Osteoarthrosis (eburnation) in all bones of the right knee
Angulation of the fractured segments	Good (< 45°): slight (9°) coronal counterclockwise angulation of the lower medial diametaphyseal fragment. In the sagittal plane the lowest fragment reaches 20° of anterior deviation
Linear / rotational deformity	Present rotational deformity: 23° of measured retroversion of the femoral neck versus the lower femur segment, showing an abnormal counterclockwise rotation of the lower supracondylar fragment
Amount of overlap / apposition	Five to six cm of cortical diaphyseal fragments overlap at the medial lower third of the femur. Due to the multiple fragments (at least three) the contact between fracture segments is not achievable
Alignment of the bone	Moderate misalignment: mediolateral and longitudinal displacement of the broken segments

The Chapel of the Holy Spirit that was destroyed in the early 20th century (Source: Anselmo Braamcamp Freire's Documentation Center of the Municipal Museum of Loures).
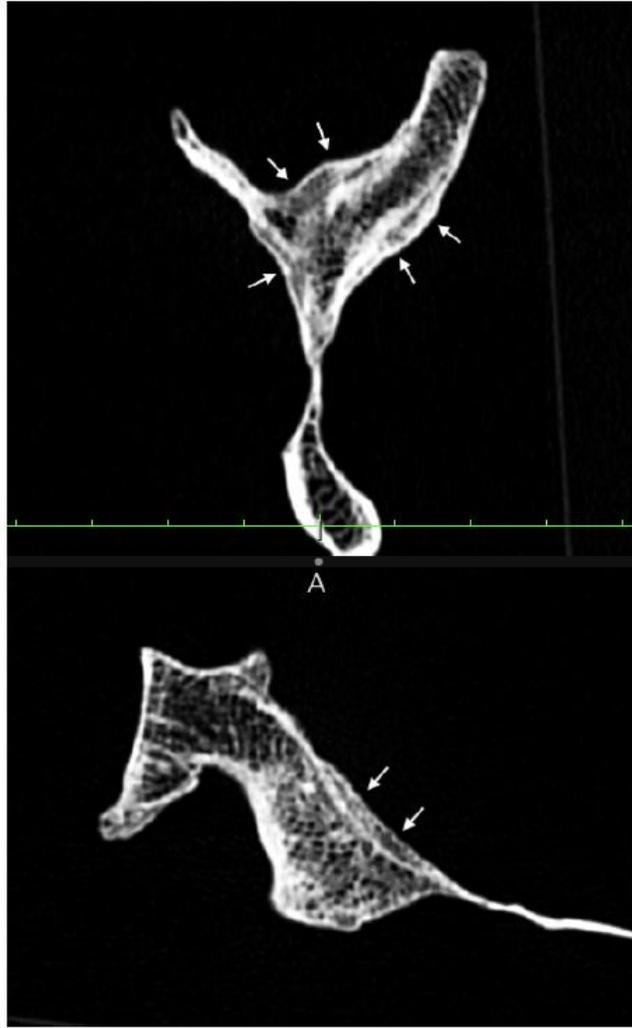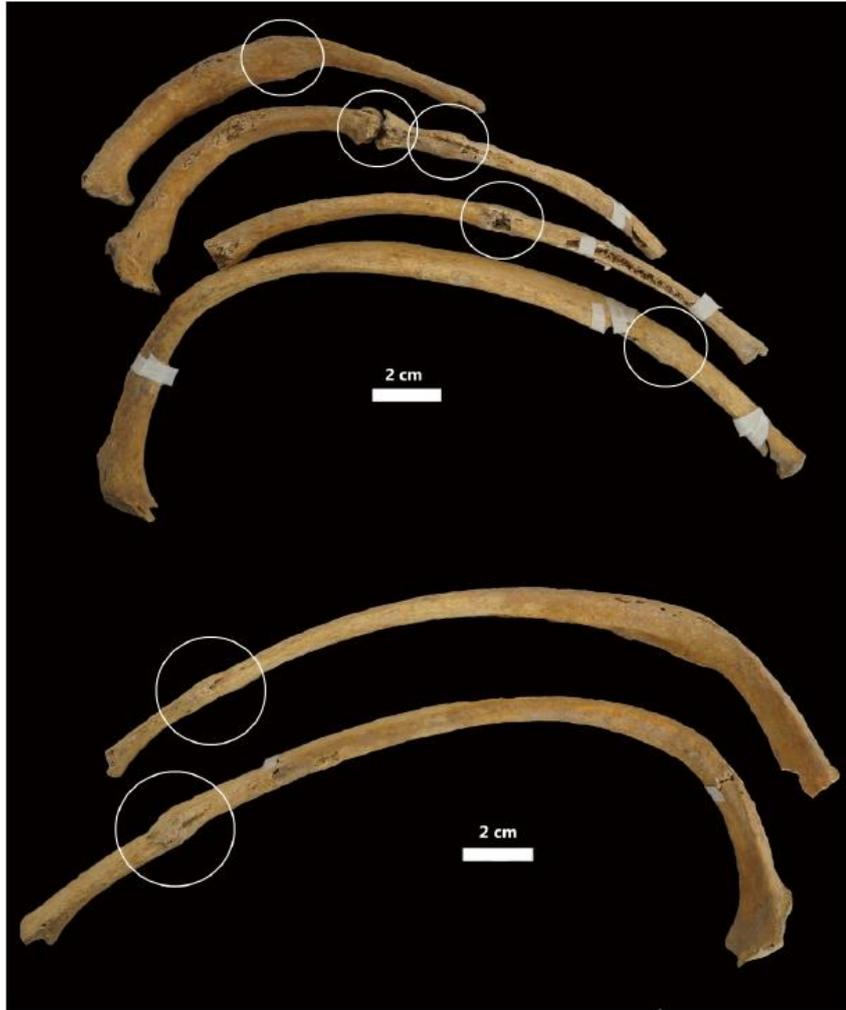
Skeleton of the male individual #15 in situ.

Injuries and fractures distribution in the skeleton. The gray color represents the bones present. The dark circles indicate the injured bones.

CT multiplanar reconstruction of oblique views (sagittal and axial) of the right scapula (arrows showing areas of new bone deposition).

Fractures in the left (above) and right (below) ribs (superior view). Notice the different locations of the fractures in the shaft and stages of remodeling.
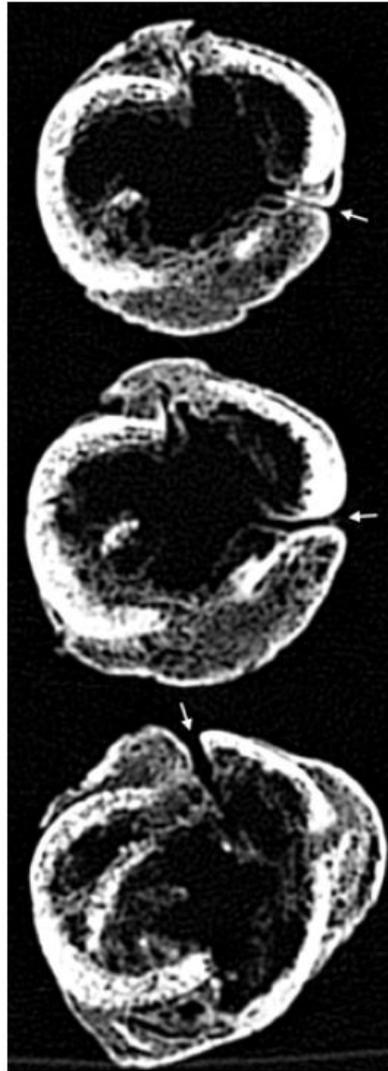
Inferior view of the 11th left rib with two fractures. The unfused fracture shows woven bone, indicating active remodeling.

Distal fracture of the right femur, with bone impaction and myositis ossificans in the proximal region: (a) CT multiplanar reconstruction coronal view of the right femur; (b) macroscopical anterior view of the right femur.

CT multiplanar reconstruction of axial views (three levels) of the lower diaphysis of the right femur (arrows showing three distinct cloacae).