Picking up the pieces: Utilizing the diagnostic potential of poorly preserved remains.

Picking up the pieces: utilizing the diagnostic potential of poorly preserved remains.

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Abstract

With pressures on time and resources available to those undertaking research in paleopathology, poorly preserved archaeological human remains can often receive limited attention or be completely excluded from the analysis of archaeological sites. Although incomplete skeletons often yield minimal demographic information and can complicate the diagnosis of some pathological conditions, this is not universal. Significant information can be obtained even in partial remains on metabolic bone diseases (where, by definition, the whole skeleton is involved), and for conditions such as osteoarthritis and fractures which can be diagnosed in isolation. We present an example of a highly incomplete skeleton which provided valuable new information on pathological changes associated with osteomalacia, a condition that has been little studied to date in paleopathology. This skeleton also contributes to our understanding of the factors surrounding the classification of fractures, and provides new insight into the full range of circumstances in which eburnation can develop. The example discussed demonstrates the value of including partial and poorly preserved skeletons in paleopathological analysis, and the extent of information that can be obtained.

1. Introduction

Time and money available for both basic analysis and research in paleopathology are frequently limited, and as a result there can be a tendency to focus on better preserved and more complete skeletons to maximize the information obtained (e.g., Brickley et al., 2006:96; Connell et al., 2012:20). Due to the limited range of skeletal changes that occur in response to disease and trauma, distribution of lesions is often important in suggesting a diagnosis (Ortner 2011:5). Diagnosis of many conditions can be difficult in incomplete skeletons, and it is also likely to be harder to evaluate sex and age-at-death, limiting interpretations of social and cultural factors. However, affording less attention to poorly preserved remains could result in loss of information on the many conditions that result in loss of bone density which contributes to poor levels of preservation; perhaps more importantly, results will be biased. Significant information can be obtained even in very partial remains in some pathological conditions. In this paper we set out the range and extent of information on new aspects of osteomalacia, fracture classification, and the development of eburnation obtained from the analysis of a very poorly preserved skeleton.

2. Case report

At Chelsea Old Church, London, UK, a higher status cemetery dating to the 18th- to early 19th-century, two individuals had lesions characteristic of osteomalacia, including multiple rib fractures and pseudofractures at the base of the acromial process of the scapula (Cowie et al., 2008; Ives, 2008). Here we focus on Skeleton OCU615. The individual was very incomplete and fragmentary (Fig. 1) and sex and age (beyond adulthood) could not be assessed. For this reason OCU615 would be a candidate for exclusion in many studies, although it was reported on and diagnosed by Cowie et al. (2008). More recently a sex assessment of female was made (Ives and Brickley in press).

Most of the bones present were lightweight, fragile and incomplete, suggesting a problem with bone density (see full discussion of diagnosis in Ives and Brickley in press). OCU615 had a pseudofracture at the base of the acromial process of the left scapula, with a large callus of disorganized woven bone which almost covers the fracture; the margins of a small linear fracture are still visible (see Ives and Brickley in press, Figure 2a.). A total of 119 rib fragments were present. Sixteen of these fragments displayed disorganized woven bone formation consistent with fracture healing. Fifteen fragments had evidence of fracture at one

end; one had evidence of fracture at both ends of the fragment. All of the fractures were ante-mortem, none were united. When adjoining fracture ends were re-associated, fourteen of the fragments could be paired up to identify seven fractures; a further three fractures were represented by just one side of the fracture (one of which was at the other end of the fragment with callus formation at both ends). A total of nine fractures were present on ribs four to eleven on the right side; seven of these were close to the angle of the ribs, two were to the midshaft. One of these ribs was fractured in two locations. One further unsided rib fragment was also fractured. Due to the fragile nature of the skeleton it was impossible to establish if any of the fractures were pseduofractures that had become separated post-mortem.

Of particular interest was the fracture 35mm from the head of rib six on the right side. An area of spiculated new bone formation surrounds the fracture margins, with two small nodules of compact bone on the rib head fragment, c.5mm from the fracture site on the visceral surface (Fig. 2A). A small area of eburnation was present at the site of the fracture on the visceral side (Fig. 2B) indicating that the non-union was chronic and that movement had occurred at the fracture site; no sclerosis was evident on the radiograph (Fig. 3). Very small areas of eburnation (<1mm in diameter) were observed on both ends of the mid-rib fragment that was fractured at both ends. These fractures are unlikely to have ever healed.

3. Discussion

Osteomalacia is a metabolic bone disease as defined by Albright and Reifenstein (1948), affecting processes of bone formation and remodeling across the whole skeleton. As a result changes linked to osteomalacia could be apparent on any bone (Milkman 1930:31) meaning complete skeletons are not required to suggest a diagnosis. The analysis of dry bone offers the opportunity to identify a wider range of changes than are described in the clinical literature, and this case clearly illustrates the range of information that can be derived from direct observation of bone. In paleopathology, one of the key features of osteomalacia is pseudofractures, which are small linear fractures in the cortex of bone frequently surrounded by irregular callus (Brickley and Ives, 2008:125). In severe cases, pseudofractures can develop into complete fractures. A wide range of terms have been used to describe pseudofractures, including Milkman's fractures, Looser's zones and linear fractures (Brickley et al., 2007:69).

In osteomalacia, pseudofractures can occur in many areas of the skeleton, with multiple fractures in a single bone (Milkman, 1930). Ribs are an area particularly affected by pseudofractures because they contain a higher amount of trabecular bone, which has a higher turnover rate than cortical bone (Ortner, 2003:399). Mankin (1974) noted that pseudofractures can develop into full fractures and it is unclear if these will heal without resolution of the underlying pathological condition. Fractures that occur in cases of osteomalacia can last for months or even years (Albright et al., 1946:402). Milkman (1930) reported a case of osteomalacia where fractures had been present in some bones for over three years (see Fig. 4).

Clinical features of non-union are described by McKee (2000). Most of these features will not be visible in skeletal paleopathology, but sclerosis of fracture ends and hypertrophic callus formation are two that would be visible in dry bone cases supported by radiography. Pseudarthrosis is often currently used clinically to describe a false joint where the fibrocartilagenous cavity is lined with synovium producing synovial fluid (McKee, 2000). Without stabilization, it is unlikely that calcification of the fibrocartilage at a non-union fracture site will take place (McKee, 2000) and a pseudarthrosis would form. Djuríc et al. (2006:169) and Lovell (1997:147) clearly describe the differences between non-union, delayed union and death during the healing process and the difficulties in distinguishing the latter two in paleopathology (see also Ortner 2003:131). However, a pseudarthrosis with a compact bone surface and sclerotic margins and/or eburnation indicates true non-union (see Fig. 5).

Eburnation will occur in any situation where two exposed bony surfaces are in contact and they are moving against one another. Contact between bony surfaces can occur in a number of circumstances and is not confined to synovial joints, but can also be observed at cartilaginous joints in a number of conditions – seen in intervertebral discs in discarthrosis, cartilaginous joints in Ankylosing Spondylitis and the pubic symphysis in osteitis pubis (Resnick, 1995:1013, 1378, 2092). A paleopathological case of osteitis pubis with extensive eburnation has been reported by Judd (2010). Experimental work undertaken on animals suggests eburnation develops fairly rapidly and the amount of movement required to produce it is limited. A study of changes at the femoral condyles in experimentally induced arthritis in rabbits demonstrated that eburnation developed in ten weeks (Calvo et al., 2001). In a study involving rats, eburnation was observed to occur between six and ten weeks post-surgery

(Hayami et al., 2006). It is not clear if differences in overall size of human joints would have an impact on the speed at which eburnation developed, and no data on the development of eburnation at fracture sites was found. In the case reported by Hayami and colleagues (2006) cartilage had originally been present across the joint surface; where no cartilage is present, for example at a pseudarthrosis, it is likely that eburnation would develop more rapidly.

4. Conclusion

The identification of non-united fractures, from indicative features including hypertrophic callus formation, sclerosis, formation of a pseudarthrosis and/or eburnation allows paleopathologists to make more complete interpretations of healing and inferences about the likelihood of union. In the example of OCU615, several rib fractures probably represent delayed union, with the osteomalacia the underlying cause for delay. The fractures to right rib six and both ends of the un-numbered right midshaft fragment, with eburnation present, represent true non-union.

Lethargy, bone pain and muscle weakness are recognized symptoms of osteomalacia (Reginato and Coquia, 2003). The non-union of three rib fractures probably caused ongoing discomfort. The remaining delayed union fractures are unlikely to have been resolved unless considerable changes occurred in the individual's lifestyle, curing the osteomalacia. Finally, this case illustrates the need to carefully observe and record even the most poorly preserved skeletons to gain a full understanding of the experience of disease in past communities. This highly incomplete skeleton provides additional evidence on osteomalacia, a condition that has been little studied to date in paleopathology and valuable information of factors surrounding the classification of fractures, and the range of circumstances in which eburnation may develop.

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Figures:

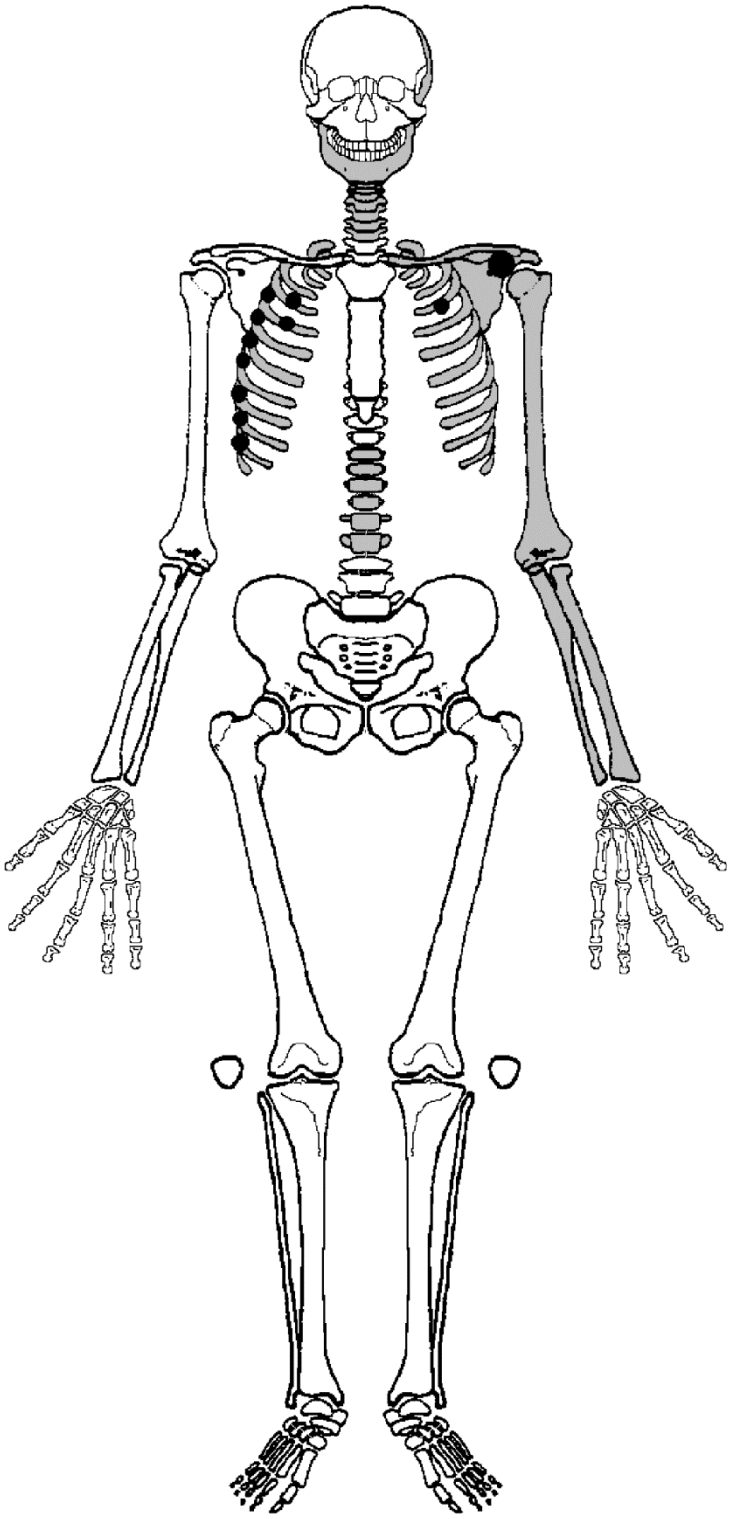

Figure 1: Inventory of bones present (grey) and distribution of pseudofractures recorded (black) in OCU615 from Chelsea Old Church, London. All of the bones were incomplete and poorly preserved.

Figure 2: Un-united fracture to the sixth right rib. 2B shows the area of eburnation at the fracture site. Arrows highlight the area of eburnation. © John Chase, Museum of London.

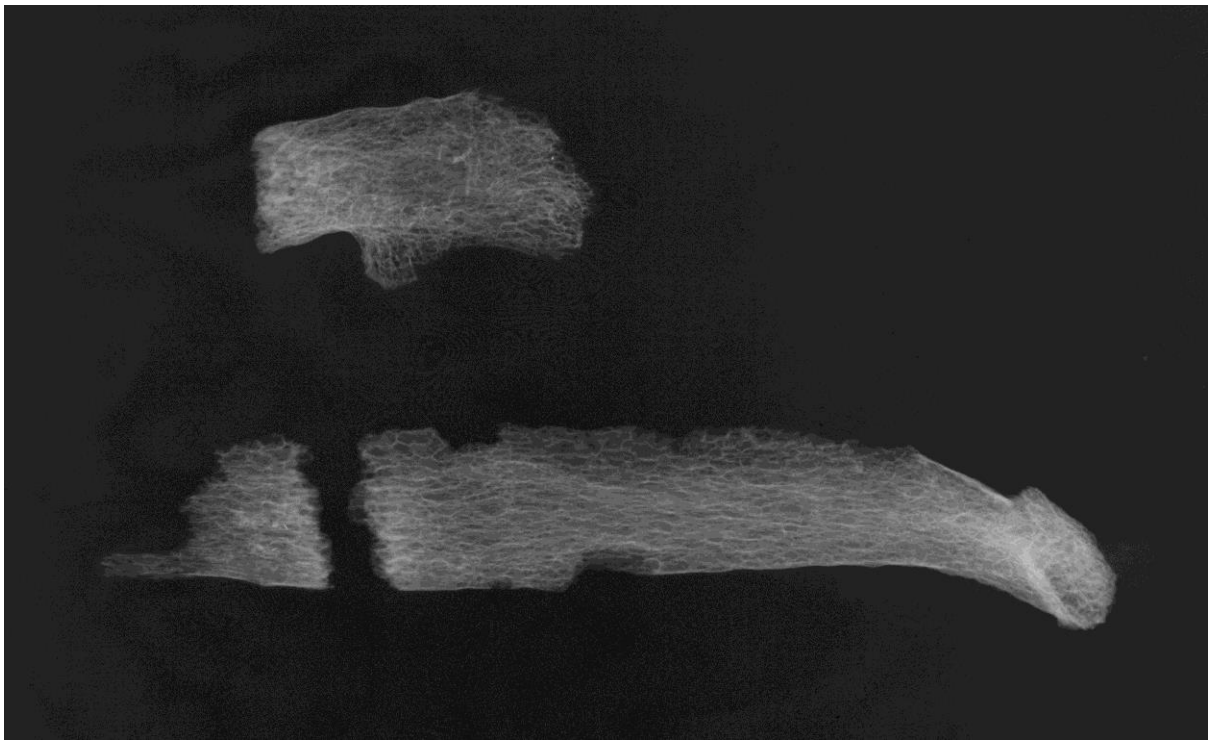

Figure 3: Radiograph of un-united fracture to the sixth right rib. © Museum of London.

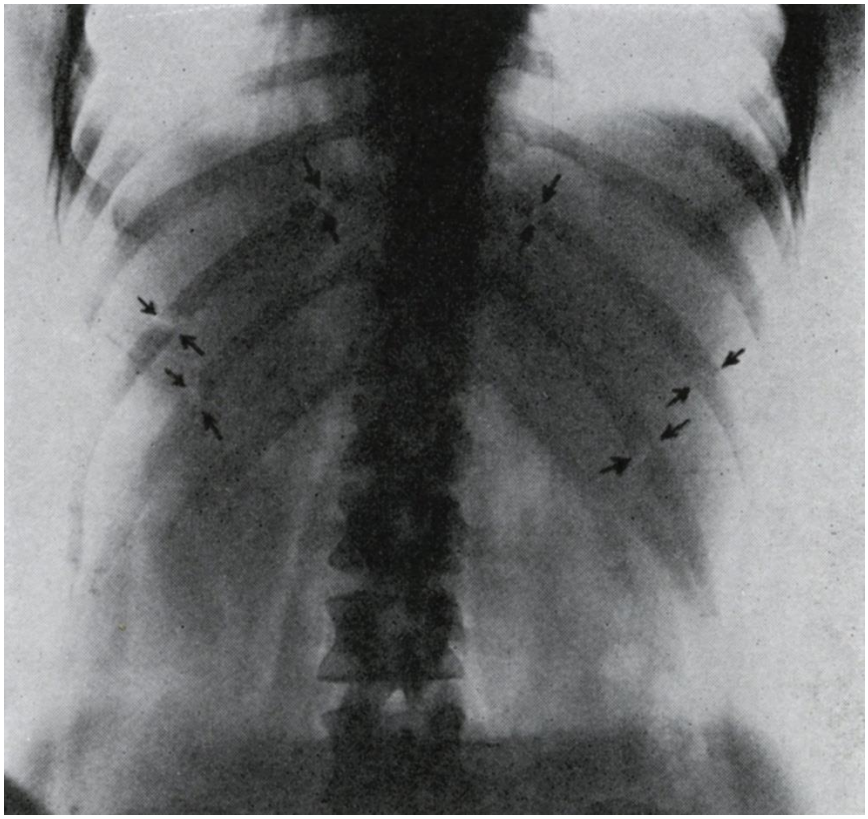

Figure 4: Roentgen of individual with osteomalacia. Multiple, symmetrical and bilateral fractures are present on the tenth and eleventh ribs. Note the transparency zones which are characteristic of these lesions (Milkman, 1930: Figure 3). Reprinted with permission from the American Journal of Reontgenology.

Figure 5: Comparison of non-union fractures in paleopathology. A) Non-union fracture of an ulna from medieval Lincoln, UK. The combination of compact bone formation around the fracture site and the porous pseudarthrosis with a small area of eburnation indicates this non-union fracture was mobile for an extended period of time; it is likely that this fracture would never have healed. Arrows highlight the areas of eburnation. B) Non-union rib fracture from medieval Lincoln, UK. The callus has started to ossify but the bone is still woven indicating this individual died before union occurred; it is impossible to establish if the fracture would have united had the individual lived and the healing process continued.