Special Report

The Radiologist in the Crypt: Burden of Disease in the Past and Its Modern Relevance

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Rationale and Objectives: Our study provides a critical assessment of osteological and radiological techniques in the analysis of bioarchaeological samples for evidence of pathology. Teams of physicians, anthropologists, historians, and archaeologists have used these methods to provide a clearer picture of health and disease burden in the past. Of relevance for clinicians, these efforts have led to a reconsideration of the physiology and epidemiology of contemporary disease.

Materials and Methods: We examined 213 18th- to 19th-century adult skeletons from the crypt of St. Bride's Church in London using two methods of skeletal analysis (osteological and radiological). All available bones were examined by an osteologist. Radiographs of the crania, humeri, pelvises, femora, and tibiae were examined by a radiologist. Identified lesions were grouped into nine standard categories used in an osteological examination, and statistical analysis was completed.

Results: Among lesion categories, and between lesion categories and age, correlations were weaker among the radiologically analyzed data than among data evaluated osteologically. Correlations between age at death and total number of lesions identified were nearly identical, regardless of the method of lesion identification.

Conclusions: Although osteological analysis seemed more sensitive in identifying infectious and neoplastic lesions, radiological analysis often provided a clearer illustration of the extent of these conditions, especially when the lesion involved a large area (eg, osteoporosis or Paget disease). Radiological analysis suggested that, as they age, men accumulate skeletal lesions more rapidly than women. Using bioarchaeological data, our study suggests the potential that radiological analysis might have in the establishment of general baseline levels of ill health in both past and present populations.

Key Words: Aging; bioarchaeology; paleoroentgenology; osteology.

INTRODUCTION

Humans have long been fascinated with their past. The Greeks and Romans who lived 2000 years ago marveled at the Egyptian pyramids, which were already more than 2000 years old when these Greco-Roman admirers speculated about their age and wondered about the secrets hidden within them (1). Today, we speculate with no less fervor about how people in the past lived—but now, we have new technologies that allow us to satisfy our curiosity and contribute to our ever-growing body of knowledge about those living centuries ago and what they can teach us about our modern lives. Advanced imaging techniques have provided answers to many questions, including those related to the health of past individuals and populations (2) and those related to contemporary populations. The Horus study, for example, used the results of computed tomography imaging to argue that evidence of atherosclerotic disease in mummies from four different populations and four different time periods emphasized how misguided we might be in attributing our clogged vasculature to our "modern lifestyle" alone (3).

Even as advanced imaging techniques have provided some answers, they have also raised more questions. Imaging of King Tutankhamun, for example, probably the most studied mummy of all, has yielded much information about his life but fewer clear conclusions about how he died (4). Interpreting the computed tomography scan of a mummy or evaluating radiographs of disarticulated bones is not as straightforward as assessing the images of a patient in a contemporary hospital: in the former case, one cannot ask the individual under study how he or she is feeling or where it hurts (or any other question about his or her life and health). The field of bioarchaeology and questions regarding how individuals died are necessarily

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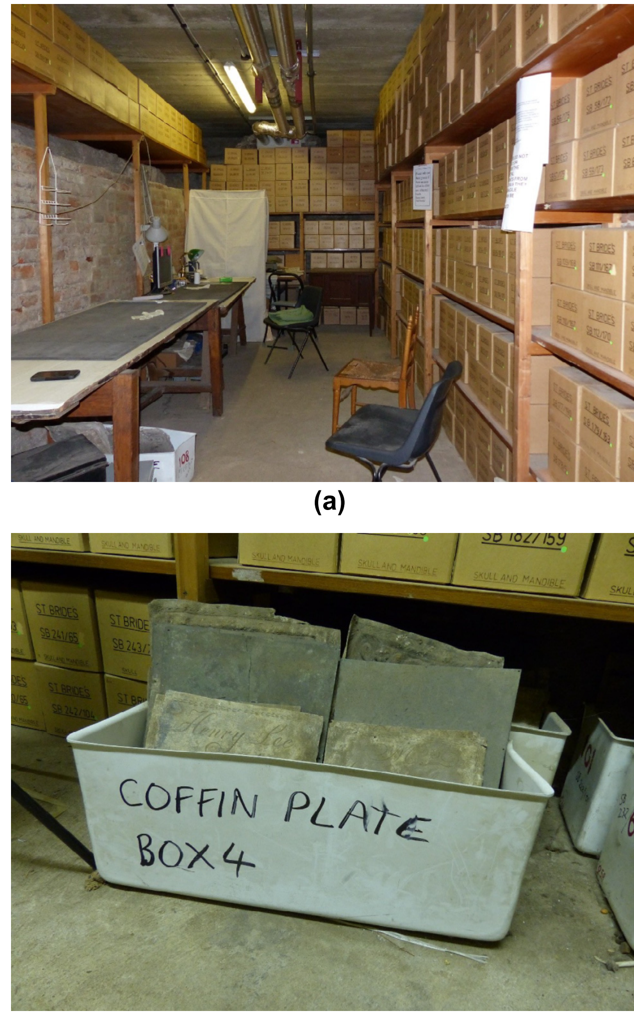
speculative, but it is often the especially speculative inquiries that pique our interest the most. Physicians, scientists, historians, and the public alike are intrigued by how the burden of disease has changed over time (5,6), even if answers about these changes are not always straightforward. Bioarchaeology is, in some respects, like medicine itself—an art simultaneously rigorous and imprecise that, although based on generalities, must still accommodate individual variation and interpretation. Standards of evaluating skeletons for lesions using accepted methods of osteological analysis and inspection have been developed, refined, and tested through decades of meticulous research and study; fewer studies have focused on developing associated standards for imaging techniques used in bioarchaeological contexts (2,7). Imaging is often employed only when osteological analysis is inconclusive, an approach that selects the "most interesting" samples for radiological analysis while overlooking the potential of imaging to identify lesions that might not be readily apparent by osteological evaluation. In other cases, the entire sample is imaged, but the number of skeletons imaged is too small for meaningful statistical analysis (8–11).

Our study had two goals. The first, an investigation of the relationship between disease and age at death, is detailed in a forthcoming article. Presented here are the results of efforts related to the second goal: a critical assessment of both osteological and radiological techniques in the evaluation of bioarchaeological samples for evidence of pathology.



(a) (b)

Figure 1. **(a)** Area of the crypt of St. Bride's Church, London, where the remains of those studied in this research are preserved. **(b)** Coffin plate representative of those used to identify the individuals interred.

MATERIALS AND METHODS

An accessible study population large enough to permit statistical analysis was found in the collection of human remains from the crypt of St. Bride's Church in London. There has likely been a church on the site of the present St. Bride's since the 7th century CE, and thousands of people were buried in the area underneath it over the course of its long history (12,13). Bombing and subsequent reconstruction of the church during and after the Second World War revealed a particularly unique set of human remains in one of the sealed crypts—for 213 of the hundreds of adult individuals interred in the church grounds during the 18th and 19th centuries, their remains were reliably associated with lead coffin plates that bore each individual's name, date of birth, and date of death (Fig 1 shows where the skeletons are currently preserved, under the curatorial care of the Museum of London, in the crypt of the church) (12,13). The presence of historically verifiable age-at-death data (here, in the form of the coffin plates) allowed an assessment of the relationship between age at death and evidence of skeletal lesions independent of aging methods that depended on the condition of the skeleton (13,14).

All of the skeletons were examined by the same experienced osteologist, who noted and recorded all potential lesions in accordance with the Museum of London's *Human Osteology Method Statement* (14). Data recording followed the procedure outlined in *A Rapid Method for Recording Human Skeletal Data* by Connell and Rauxloh (15). Pathologic conditions suggested by the lesions were listed according to macro-level pathology codes as outlined in the *Rapid Method* manual (congenital, infectious, joints, trauma, metabolic, endocrine, neoplastic, circulatory, and miscellaneous), with these macro levels further differentiated into more specific pathologic diagnoses. When possible, the degree of severity was recorded as a quantifiable number based on accepted criteria.

Radiographic imaging used in the present study was carried out on crania (excluding dental pathology), femora, tibiae, pelvises (including sacra), and humeri with a Sedecal 4.0-kW X-ray generator (Sedecal) and a Canon Lanmix 35 cm × 43 cm flat plate digital detector (Canon). Cranial radiographs and photographs had been previously obtained in 2010–2011 for a separate project using the same radiographic equipment and radiographer involved in the present study. Radiographs and photographs of the postcranial skeleton were taken specifically for the present study. Analysis of the radiographs was completed at a large, academic tertiary care medical center using a DICOM viewer. When initially viewing the images