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A new method for identifying and differentiating human dissection and autopsy in archaeological human skeletal remains

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ABSTRACT

Since the medieval period, anatomical dissection has been performed to examine the normal structures of a body for educational purposes, while autopsy was undertaken to determine cause of death. Although different in their objectives, significant overlap is seen in the archaeological record. The tool marks found on the skeleton including evidence of a craniotomy or thoracotomy, and the archaeological context of a hospital burial ground, may be associated with both dissection and autopsy. Due to the difficulty of differentiation, the aim of this study is to identify new criteria for detecting and differentiating human dissection and autopsy in archaeological assemblages. To achieve this, historical dissection and autopsy manuals were consulted and the crania of 140 individuals, dated between 1849 and c. 1913, were analysed from the retained dissected material from the University of Cambridge. The results show that tool marks are present on over 80% of individuals, but only 55% of the crania had been sawn open. This finding is inconsistent with the historical dissection manuals, which suggest that in student dissections the internal structures in the skull are always examined. Interestingly, 59% of the unopened crania had evidence of superficial knife marks on their external surface, suggesting that the presence of knife marks on an unopened cranial vault is an important diagnostic criterion for identifying human dissection across all age groups. It is believed that these skulls were intentionally unopened and retained as teaching material. This criterion complements other signs of dissection including the division of the corpse into sections, bisection of the cranium, presence of coloured dyes, dissected animal remains in the grave, and coloured wax injections of hollow organs. In contrast, a skeleton with circumferential craniotomy alone or with a thoracotomy is most likely to indicate autopsy.

1. Introduction

In recent years a number of archaeological excavations have uncovered evidence of sharp-force blade trauma on human skeletal remains consistent with post-mortem surgical procedures. These include investigative procedures such as human dissection, autopsy and the creation of pathology museum specimens (Boston et al., 2008; Chamberlain, 2012; Cherryson, 2010; Fowler and Powers, 2012; Kausmally, 2012; Mitchell, 2012; Webb et al., 2014; Witkin, 2011). This collection of evidence has allowed for a vast amount of information about the history of medicine and medical education to be gleaned but has also raised many questions and highlighted several concerns about correctly differentiating post-mortem medical procedures. Traditionally the context in which skeletal remains are found provides the first clue in interpreting sharp-force trauma. Disarticulated or comingled remains in burial locations associated with a hospital or universities known to have taught anatomy are more likely to have evidence of human dissection. Examples of autopsy are more commonly found than examples of dissection in formal inhumation burial contexts. However, many recently excavated sites include examples of medical waste from surgical procedures, human dissection, autopsy, as well as discarded teaching and museum specimens, being able to differentiate them is of paramount importance to correctly interpret the assemblage.

Differentiating between historical surgical procedures and types of post-mortem investigative procedures is complicated by the fact that the majority of surgical intervention would only have affected the soft tissue rather than the bone, and therefore evidence of these procedures will be lost as the body decays. Evidence of surgical procedures performed during the 18th and 19th centuries that can be observed on the skeleton are generally restricted to amputations and trephinations (Aitken, 1779; Fergusson, 1845; Warner, 1784). When undertaken on patients during life, both procedures tend to be limited to a single skeletal element. Examples of these procedures are occasionally found in archaeological assemblages (Boston et al., 2008; Chamberlain, 1999; Connell and Miles, 2010; Kurin, 2013; Witkin, 1997).

More difficult to distinguish are human dissection and autopsy. Autopsy is an invasive procedure on a corpse performed only to determine the cause of death. Past medical manuals show that this procedure was generally restricted to opening the skull and the thoracic and

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abdominal cavities to examine the vital organs located there (Harris, 1887; Virchow, 1880). In contrast, the purpose of anatomical dissection was to thoroughly examine the structure of the entire body for educational purposes (Ellis, 1840; Holden and Langton, 1868). Although different in their objective, significant overlap is seen in the archaeological evidence for these procedures (Cherryson, 2010; Fowler and Powers, 2012; Mitchell et al., 2011). For example, both autopsy and dissection may include a circumferential craniotomy, a procedure where the top of the cranium was sawn open so that the brain and internal structures could be examined. The removal of the top of the cranium in a live patient would be fatal, and is not described as a treatment in past surgical manuals (Aitken, 1779; Fergusson, 1845). A further component of both autopsy and dissection was to open up the chest through a procedure called a thoracotomy. This can be accomplished by either sawing through the sternum, via a sternotomy (Ellis, 1840), or by sawing through the costoclavicular cartilage connecting the ribs on each side (Harris, 1887; Holden and Langton, 1868; Virchow, 1880). Consequently, neither of these post-mortem procedures is helpful in differentiating autopsy from dissection.

To complicate matters further, cadavers were not always used for a singular purpose and multiple procedures for various reasons may have been carried out on a single cadaver. During dissection, for example, portions of the body may have been removed and preserved in anatomical museums. The creation of these preparations will affect the pattern of tool marks found on the skeletal remains. This will make identifying and differentiating between these procedures more complex. Additionally, it is possible for an individual to firstly undergo autopsy and then dissection (Hurren, 2012).

It is well established that the analysis of sharp-force blade trauma including knives and saws on archaeological human skeletal remains can provide key information about past societies. Recent research includes examination of warfare practices (Fiorato et al., 2000) and tool use in 19th century surgical practices (Dittmar-Blado and Wilson, 2012). This is achieved by differentiating between the tool classes, through macro- and microscopic analysis of the tool marks found on archaeological skeletal remains (see Symes et al., 2010). However, surgery, autopsy and dissection were all generally performed using the same medical instruments, which further complicates differentiation between types of post-mortem examinations (Savigny, 1793–1795; Savigny, 1800; Weiss, 1863).

Problematically, the location of the cemetery does not always help us differentiate autopsy from dissection either. Hospital cemeteries may include individuals who had undergone either procedure, as seen at the excavation of the Royal London Hospital, Whitechapel (Fowler and Powers, 2012). Some poor-house burial grounds and public cemeteries include individuals who had undergone autopsy or dissection in a hospital or medical school and were then returned to be buried away from the relevant hospital (Chamberlain, 2012).

Due to the difficulty interpreting the archaeological evidence, a set of criteria to differentiate these procedures is needed. Firstly, a better understanding of how autopsies and dissections were conducted in the past is required. This can be achieved by studying the historical autopsy and dissection manuals and comparing them to historic surgical instruction texts. Then we must study a documented skeletal sample where it is known that the individuals all underwent anatomical dissection and not autopsy. Ideally study of an equivalent documented skeletal sample of autopsies could be conducted in parallel but unfortunately no such skeletal series currently exists. However, using the approach we outline here allows us to be as confident as we can that the criteria identified are secure and robust. The aim of this study is to use such an approach in order to outline newly identified criteria on cranial elements for identifying human dissection and differentiating between dissection and autopsy in archaeological assemblages.

2. Materials and methods

2.1. Materials

Three historical autopsy manuals (Harris, 1887; Rolleston and Kanthack, 1894; Virchow, 1880) and three anatomical dissection manuals (Ellis, 1840; Holden and Langton, 1868; Read, 1642) dating from the 1640s to the late 1880s were consulted in order to identify how human dissection and autopsy procedures were undertaken. Texts which describe how to create and preserve anatomical preparations were also selected for analysis due to the common practice of selecting portions from cadavers in the dissecting room (Pole, 1790; Swan, 1815). Surgical texts from the late 1700s to the late 1800s were consulted to determine if there were any life-prolonging procedures that shared similar tool marks patterns to the post-mortem procedures (Aitken, 1779; Fergusson, 1845; Horsley, 1886; Warner, 1784). Multiple historical manuals were selected to try to normalise the variation in techniques seen during this time period. Only the procedures which affect the skeletal system will be discussed within this paper.

The crania of 140 individuals were selected for analysis from the retained dissected human skeletal remains from the dissecting room in the Anatomy Department at the University of Cambridge. In this study, to the best of our ability, only skeletal material dissected at the University of Cambridge that could be verified with historical documentation was selected for analysis. By selecting crania described as coming from the 'dissecting room' we tried to insure that the intended purpose of these cadavers was dissection in order to accurately examine the location of tool marks associated with human dissection for teaching anatomy. Based on the context in which these crania were found, it is likely that these cadavers played multiple roles in anatomical teaching and some of these crania were retained in the anatomical museum.

Two sources were used to date the skeletal material analysed. The first source, an unpublished catalogue of the Anatomical Museum collections at the University of Cambridge, was used to determine the dates when the material was acquired up until 1883 (Humphry, unpublished). The second source was the Duckworth Catalogue, an unpublished manuscript, which was consulted to confirm the origin and dates of the crania after 1883 (Duckworth, unpublished). Any cranium included in this sample pre-dates the end of this catalogue and many have exact dates of when they entered into the collection, all of them prior to 1913.

The crania were initially divided into age classes as outlined in Buikstra and Ubelaker (1994); foetus (prenatal), infant (0–3 years), child (3–12), adolescent (12–20), adult (20+). The historical records were used to provide specific ages to the majority of the juvenile and foetal crania. In cases where historical documentation was not specific, dental formation and eruption (Ubelaker, 1989) were used to determine the age of the juveniles. Three infant crania were identified and the age of death listed for each individual was less than three months old. As this study is examining the patterns of tool marks in post-mortem practices the authors feel it is appropriate to include these crania in the 'foetal' category with the other crania of comparable size. Due to the small number of individuals in the 'child' and 'adolescent' category, we have combined these two categories together and they are listed as 'juveniles'. The three age classes examined in this study are: foetal (premature and up to 3 months after birth), juvenile (age 1–20) and adult (over 20). The sample consisted of 51.8% adults ($n = 73$), 9.2% juveniles ($n = 13$) and 38.3% foetuses ($n = 54$).

2.2. Methods

The crania were macroscopically analysed and the location of the knife and saw marks were recorded and digitised. Tool mark types were differentiated using methods outlined in Symes et al. (2010). Saw marks were identified by their morphological appearance as characterised by wide, square incisions with a flat floor and vertical