Worcestershire Archaeology Research Report No.3

Osteological Analysis of Human Remains from the

WORCESTER ROYAL INFIRMARY, CASTLE STREET, WORCESTER

A G Western and T Kausmally

Worcestershire Archaeology Research Report no 3

Osteological Analysis of Human Remains from the Worcester Royal Infirmary, Castle Street, Worcester

(WCM 101627)

A G Western and T Kausmally

worcestershire county council

2014

Worcestershire Archaeology Research Report no 3

Osteological Analysis of Human Remains from the
Worcester Royal Infirmary, Castle Street, Worcester

Published by Worcestershire Archaeology
Archive & Archaeology Service,
The Hive, Sawmill Walk,
The Butts, Worcester.
WR1 3PD

ISBN 978-0-9929400-3-4

Worcestershire,County Council
County Hall, Spetchley Road, Worcester.
WR5 2NP

Front cover illustration: dissected cervical and upper thoracic vertebrae with bissected axis

to previous view

Contents

go to next page

to previous view

Figures

go to next page

Plates

to previous view

go to next page

to previous view

Abstract

A watching brief carried out during March 2009 and June 2010 at the site of the former Worcester Royal Infirmary, Castle Street revealed three pits containing disarticulated human remains. Further remains were found in a disturbed layer. Dating evidence from assessment of associated finds in the pits, including hospital equipment and wares, as well as from stratigraphic analysis, suggests that these remains dated to the 18th and 19th centuries and were directly associated with the Infirmary.

Osteological analysis of the human remains from the waste pits produced intriguing bioarchaeological data, reflecting the role the Infirmary played in the treatment of particular diseases of the Worcester population and its function as a teaching hospital. A bias towards males was observed in the population, and whilst all ages were represented, the majority of the skeletal elements were adult. The remains revealed evidence of high levels of inflammation, infection and peri-mortem trauma compared to local post-medieval assemblages and many elements had been subject to surgical modification and post-mortem examination. Some modifications also suggested that dissection was part of the practical learning experience of students at the Infirmary. A small quantity of faunal remains was also recovered from the pits but these did not exhibit any modifications outside of those associated with butchery.

A closer examination of the patterns of post-mortem modifications compared to those from contemporary metropolitan hospitals and anatomical study schools suggested that, whilst the pits contained skeletal material representing hospital waste from amputations, evidence for dissection and anatomical study was significant. Due to the difficulty of obtaining remains for study prior to the Anatomy Act of 1832, the Infirmary is likely to have exploited any opportunity arising to examine remains and body parts. The distinctions made today in modern clinical practice between post-mortem examination and anatomical dissection may then have been less strictly adhered to in Victorian medical investigations. The assemblage from the Worcester Royal Infirmary, one of the largest reported to date associated with a provincial hospital, importantly provides physical evidence of the striving for an ethical balance between providing successful surgical treatment and the pressures deriving from the legal restrictions placed upon pioneering medical researchers of the period.

go to next page

to previous view

Introduction

The aim of this report is to present the data collated from the osteological analysis of human skeletal remains recovered during a watching brief from the site of the former Worcester Royal Infirmary, Castle Street (grid reference: SO 8465 5525, Historic Environment Record reference WCM101627). The watching brief was carried out by Worcestershire Archive and Archaeology Service between March 2009 and September 2012 on behalf of the University of Worcester in preparation for the development of a new city centre campus. Four contexts (5001, 5003, 5008 and 10003) containing disarticulated human remains were thought to be associated directly with the Infirmary (Fig 1).

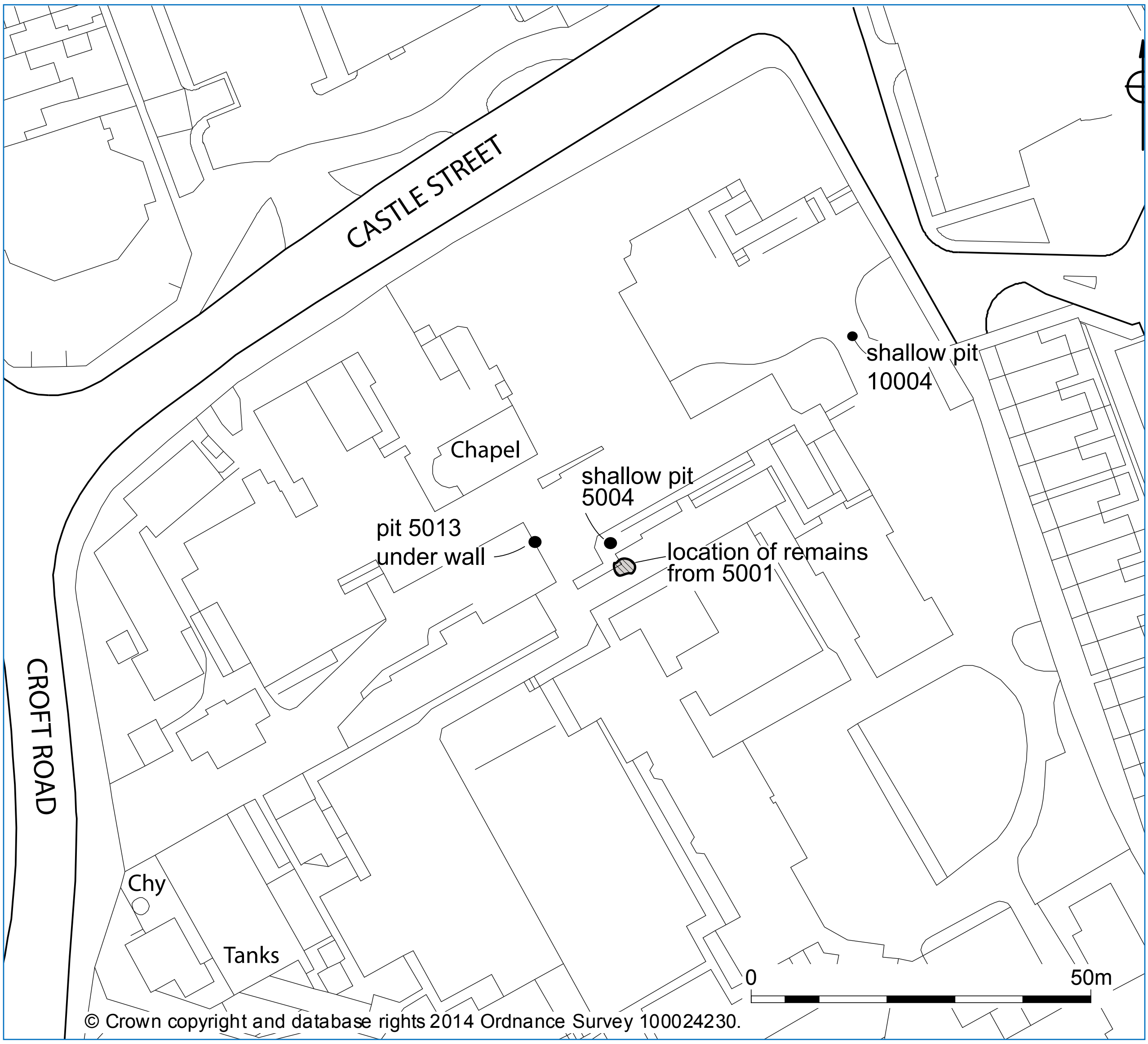

Figure 1: Location of the pits containing human remains

go to next page

to previous view

The archaeological deposits and artefacts

by C Jane Evans, Simon Sworn and Simon Woodiwiss

Context 5001 consisted of recently disturbed ground whereas the other three contexts were contained within pits. Context 5003 was a fill of pit 5004, which contained the majority of the skeletal remains. Pit 5004 was oval in plan and quite large (2.25x2.00m) but shallow (0.18m), and was not related to any other stratified deposits (Plate 1 and Fig 1). Context 5008 was one of the fills of pit 5013 (Plate 1). This was also substantial in plan, but being underneath a building wall and heavily truncated, the only recordable dimension in plan was 2.50m (Plate 2). This pit was, however, the deepest of the three (1.15m). Whereas all of the human remains were recovered from the shallow pit 5004, the presence of the wall prevented complete removal from the second pit 5013. The third pit 10004, filled by 10003, was smaller than the others at 1.15m wide and was also shallow (0.15m; Plate 3). It is also likely that human remains survive *in situ* elsewhere in the vicinity.

Plate 1: Human remains within the shallow pit 5004 (photo: Tim Cornah)

Plate 2: Human remains within the deeper pit 5013 (photo: Tim Cornah)

go to next page

Plate 3: Human Remains within the shallow pit 10004 (photo: Tegan Cole)

The earliest phase of construction of the Infirmary dates to 1767–70 (James Dinn pers comm). The wall truncating the deeper pit 5013 has been given a date of 1932–8 by Karl Hulka. Finds associated with the human remains indicate a 19th century *terminus post quem* for contexts 5001 and 5003, and later 18th century for 5008. The assemblages from contexts 5001 and 5003 were mixed, containing material of 18th century date onwards, and it is possible due to retrieval under watching brief conditions, that the later material may be intrusive. This is a particularly strong possibility in the case of context 5003, where the feature has been allocated a *terminus post quem* on the basis of a single piece of modern tile, with all other finds from this group being of similar date to those from context 5008. The majority of the finds assemblage was made up of domestic material including pottery in the form of earthenwares and china, building material consisting of brick, tile and wall plaster fragments and bottle glass. However, there was a small group of finds which could be more closely associated with the Infirmary.

Three medical implements (Fig 2) were associated with the human bone assemblage, kindly identified by Alan Humphries, Dr Claire Jones and Catriona Smellie.

1. Copper alloy attachment from a medical implement. This has been identified by Dr Claire Jones as the end of a stricture dilator for the urethra (Thompson 1868, 247, 3348). Dr Jones notes that these instruments often came in many different sizes and were used to unblock the passage, the ends often opening up to widen the passage. Length 48mm, max width 46mm. Fill 5005.

2. Copper alloy end of a stricture dilator, similar to above. Length 50mm, max width 50mm. Trench 10, fill 10003.

3. Composite medical implement with an iron shaft and an ebony handle attached by rivets. The handle has hatched serrations, to improve grip. The use of such hatching on handles for medical tools declined after *c* 1800 when it was discovered that the hatching stored germs (Catriona Smellie, pers comm). It did not, however, stop

completely and tools may also have continued in use for some time. The shaft has a groove on one side, for part of its length (from the tip to roughly 6cm up the shaft). It is badly corroded, suggesting that it is made from carbon steel rather than the nickel silver used in some medical implements. This object has been identified by Alan Humphries of the Thackray Medical Museum as a Simpson type, bladder sound or uterine sound (pers comm). Alan Humphries felt that the implement was too thin to be a rectal bougie, the original interpretation, and that the shaft looked too solid in the x-ray for it to have been a catheter. Length 217mm. Trench 10, fill 10003.

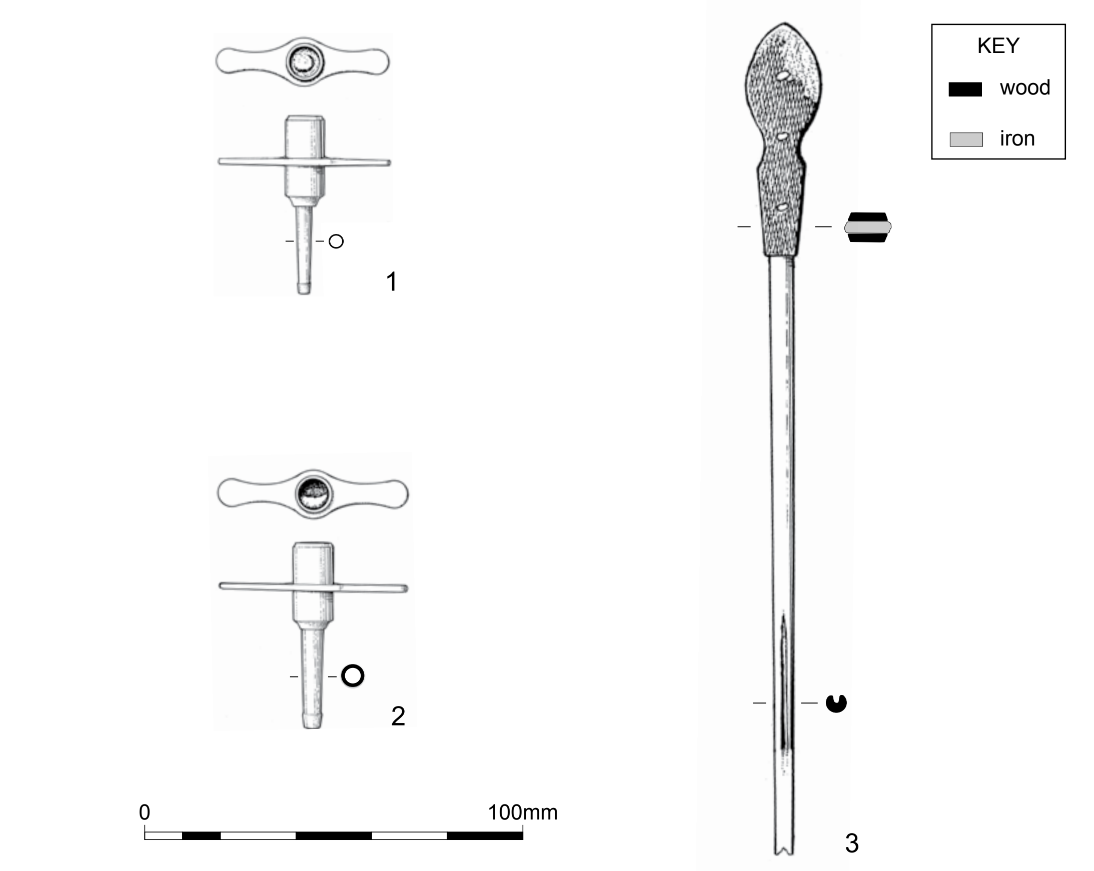

Figure 2: Medical instruments

A small assemblage of post-medieval glass was also recovered. The only directly medical item was a clear glass stopper from a narrow mouthed bottle (Plate 4), from fill 5003. This probably came from a dispensary bottle (Homan 2003). Context 5001 produced two bottle bases and a few other fragments of bottle glass. Both the bottles, probably for wine, beer or spirits, were hand blown, and had rough pontil marks. One was in a mid-olive green glass and the other in an amber brown glass. The shape of the bottles suggests they were produced later than *c* 1780. The fact that they are not mould blown suggests an end date for production, though not necessarily use, *c* 1820–30, this being the date when the production of mould blown glass becomes common. Although not strictly medical items, these are not a surprising find in the assemblage. Beer was brewed at the infirmary in the 19th century (McMenemey 1947, 232), and the quantities of wine and spirits consumed in the hospital were, at times, recorded as being 'heavy' (*op cit* 275), explained by the 'number of cases of chronic disease requiring continual support'. The remainder of the glass, from fill 5003, comprised two further fragments of green bottle glass, three fragments of window glass, a tiny fragment of opaque, pale blue glass, and a fragment of pale green glass from a thin-walled vessel. The form of the latter cannot be identified, but as it had a very curving profile is unlikely to be from a medicine or dispensary bottle.

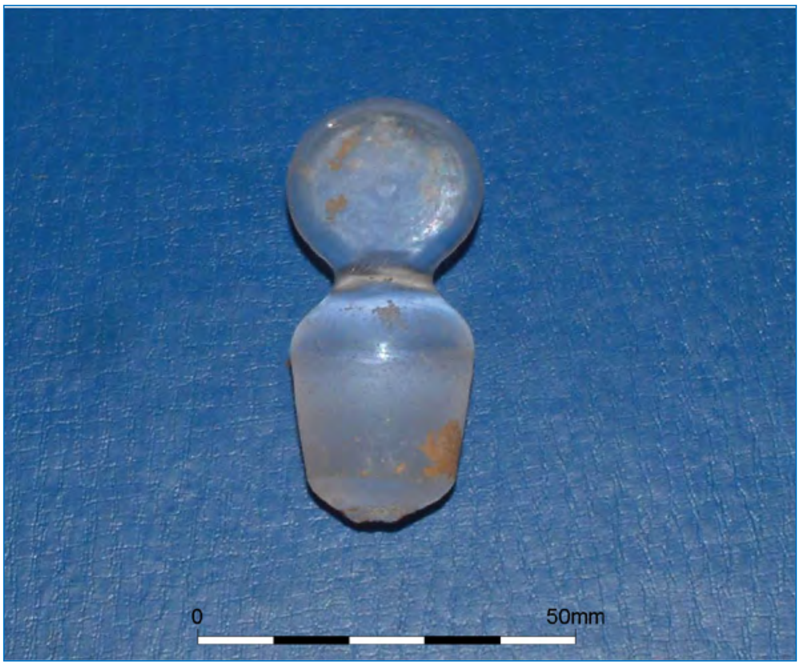

Plate 4: Glass stopper

The final piece was a fragment of opaque white glass tile (pit fill 5003), *c* 9mm thick and with close set parallel grooves on the reverse, presumably for keying the tile onto the mortar.

Only one of the pottery vessels had a probable medical function; the lower part of a plain, tin-glazed (Fabric 82) drug pot from fill 5001. The small base suggests a later 18th century date for this vessel (Draper 1984). Another find, from fill 5001, was an unusual, thick walled and crudely finished, salt-glazed, stoneware vessel, represented by an oval base and a grooved rim, not joining but presumed to be from the same vessel. No parallels have been found for this vessel by this author. It is likely to have had a very utilitarian function, possibly a bed warmer. The black glazed, red earthen wares (Fabric 78) included a rim and other sherds from a chamber pot. This could have been intended for use on the wards, or by the hospital staff.

Most of the pottery recovered relates to the food preparation and consumption that took place in the hospital, the latter by both patients and staff. Fill 5001 produced some large sherds from a Staffordshire-type slipware, press-moulded baking dish (Fabric 91). This dish, which has a pie crust rim and combed decoration, is an 18th to 19th century type. The remaining sherds comprised table wares. Amongst these were fragments from cream ware vessels (Fabric 84); white ware china (Fabric 85), including blue striped industrial slipware, a willow pattern platter, and a transfer printed plate (Fabric 85); and a small fragment of late 18th century porcelain (Fabric 83).

Fabric numbers refer to the Worcestershire Ceramic On-line Database fabric series (http://www.worcestershireceramics.org).

to previous view

Few early medical records for the Infirmary survive so the human remains recovered from the watching brief will provide a unique insight into medical treatment and anatomical study at the hospital. The data presented here will be set in the context of evidence for health and disease in the post-medieval period from urban skeletal populations as well as considering contemporary medical knowledge and treatment at similar hospital sites.

go to next page

to previous view

Worcester Royal Infirmary and post-medieval health

Health, disease and medical intervention

A report on the cases attended by Charles Hastings, MD (appointed as one of the physicians at the Worcester Infirmary in 1818 and later to become a revered medical reformer), from 1st January 1840 to the 1st January 1841 provides a useful insight into the types of diseases being treated by the hospital during the Victorian period (Hastings 1841, 342–4). Whilst many of these diseases would have left no traces in the human skeleton, the report confirms that some diseases such as syphilis and tuberculosis (phthisis) as well as non-specific conditions like 'diseased lungs' and 'inflamed legs' that may be identified skeletally were being treated (Figs 3 and 4). The report also confirms that post-mortem examinations were regularly carried out by this time and in fact, McMenemey (1959, 43) reports that Herbert Cole, the house surgeon, made post-mortem examinations in 1819. A dedicated post-mortem room was present in the hospital by 1870, when a new drainage and water supply system was installed in order to combat epidemics within the wards (Swete 1882, 563).

WORCESTER INFIRMARY.

A REPORT OF CASES ATTENDED AT THIS HOSPITAL.

BY CHARLES HASTINGS, M.D. F.G.S. &c.

From January 1st, 1840, to January 1st, 1841.

IN CASES.

	Quarter ending Mar. 31st.		Quarter ending Jun. 30th.		Quarter ending Sep. 30th.		Quarter ending Dec. 31st.		TOTAL.	
	Cases.	Died	Cases.	Died	Cases.	Died	Cases.	Died	Cases.	Died
Amaurosis	...	...	...	...	1	...	...	...	1	
Amenorrhœa	3	...	1	...	2	...	4	...	10	
Anasarca	1	...	1	...	1	...	2	...	5	
Aneurism	...	...	...	...	1	...	1	...	2	
Ascites	3	...	1	...	...	...	1	...	5	
Bronchitis	2	...	3	...	...	...	...	...	5	
C. Bronchitis	...	...	...	...	...	...	1	...	1	
Cardiac disease	1	...	1	...	3	...	3	...	8	
Carditis	...	...	1	...	2	...	...	...	3	
Cephalalgia	...	...	2	...	2	...	1	...	5	
Chlorosis	...	...	...	...	...	...	1	...	1	
Cough	2	...	2	...	1	...	3	...	8	
Colica Pictonum	...	...	1	...	...	...	...	...	1	
Constipatio	...	...	...	...	...	...	1	...	1	
Delirium Tremens	...	...	...	...	1	1	...	...	1	1
Dyspnœa	5	...	3	...	2	...	2	...	12	
Dyspepsia	1	...	1	...	1	...	1	...	4	
Emaciation	1	...	1	...	...	...	1	...	3	
Enlarged Glands	...	...	...	...	...	...	1	...	1	
Enteritis	...	...	...	...	1	...	1	1	2	1
Epilepsia	...	...	1	...	...	...	...	...	1	
Erythema	...	...	...	...	2	...	...	...	2	
Febris	...	...	8	4	...	...	2	...	10	4
Gastritis	2	...	...	...	2	...	...	...	4	
Hæmoptoë	2	...	...	...	1	...	...	...	3	
Hepatic Diseases	...	...	2	...	1	...	...	...	3	
Hepatitis	1	...	1	...	3	...	1	...	6	
Hypertrophia	1	...	...	...	...	...	...	...	1	
Hydrothorax	1	...	...	...	...	...	...	...	1	
Hysteria	...	...	...	...	...	...	1	...	1	
Inflamed Legs	1	...	...	...	...	...	...	...	1	
Iregular Action of the Heart	...	...	...	...	...	...	1	...	1	
Larynx, diseased	...	...	1	...	...	...	...	...	1	
Lepra	...	...	1	...	1	...	1	...	3	
Liver, diseased	...	...	...	...	1	...	1	...	2	
Lumbago	...	...	...	...	2	...	...	...	2	
Lungs, diseased	2	...	...	...	2	...	...	...	4	
Menorrhagia	...	...	1	...	2	...	3	...	6	
Œdema	2	...	...	...	...	...	...	...	2	
Palpitatio	...	...	...	...	2	...	1	...	3	
Paralysis	1	...	...	...	1	...	2	...	4	
Pericarditis	1	...	...	...	...	...	...	...	1	
Peritonitis	...	...	...	...	1	...	...	...	1	
Phthisis	1	1	1	...	3	...	1	...	6	1
Pleuritis	2	...	...	...	...	...	...	...	2	
Pneumonia	1	...	2	...	1	...	2	...	6	
Prolapsus Uteri	1	...	...	...	...	...	...	...	1	
Psoriasis	1	...	...	...	1	...	1	...	3	
Rheumatism	4	...	5	...	3	...	3	...	15	
Chronic Do.	2	...	1	...	3	...	2	...	8	
Splenic Disease	...	...	1	...	...	...	...	...	1	
Synochus	1	...	...	...	...	...	...	...	1	
Valvular Disease	...	...	...	...	2	...	...	...	2	
Vertigo	...	...	...	...	...	...	1	...	1	
Vomiting	1	...	...	...	...	...	...	...	1	
TOTAL	47	1	43	4	52	1	47	1	189	7

Figure 3: In-cases reported by Charles Hastings at the Worcester Royal Infirmary (Hastings 1841)

	Quarter ending Mar. 31st.		Quarter ending June 30th.		Quarter ending Sep. 30th.		Quarter ending Dec. 31st.		TOTAL.	
	Cases.	Died	Cases.	Died	Cases.	Died	Cases.	Died	Cases.	Died
Amenorrhœa	6	...	2	...	6	...	3	...	17	
Anasarca	...	...	...	...	1	...	1	...	2	
Apoplexy	1	...	...	...	...	...	1	...	2	
Ascites	1	...	...	...	...	...	1	...	2	
Asthma	...	...	...	...	2	...	...	...	2	
Bronchitis	6	...	2	...	1	...	1	...	10	
C. Bronchitis	1	...	1	...	1	...	...	...	3	
Bronchocele	3	...	...	...	...	...	...	...	3	
Cachexia	2	...	...	...	...	...	...	...	2	
Cardiac affection	2	...	3	...	6	...	1	...	12	
Cephalalgia	...	...	...	...	3	...	2	...	5	
Chlorosis	...	...	...	...	...	...	1	...	1	
Chorea	1	...	...	...	...	...	...	...	1	
Colica Pictonum	...	...	1	...	1	...	...	...	2	
Cough	1	...	2	...	...	...	2	...	5	
Croup	...	...	...	...	1	...	...	...	1	
Debility	...	...	...	...	2	...	...	...	2	
Diabetes	1	...	...	...	...	...	...	...	1	
Diarrhœa	1	...	...	...	3	...	1	...	5	
Dysmenorrhœa	...	...	...	...	...	...	1	...	1	
Dyspnœa	4	...	2	...	2	...	2	...	10	
Dyspepsia	5	...	2	...	3	...	3	...	13	
Dysuria	1	...	...	...	1	...	...	...	2	
Emaciation	1	...	...	...	...	...	...	...	1	
Enlarged Glands	...	...	...	...	...	...	1	...	1	
Epilepsia	...	...	...	...	1	...	1	...	2	
Epistaxis	1	...	...	...	1	...	...	...	2	
Fever	1	...	...	...	1	...	1	...	3	
Gastritis	1	...	...	...	...	...	...	...	1	
Chronic G.	2	...	1	...	1	...	...	...	4	
Hemiplegia	1	...	1	...	...	...	...	...	2	
Hæmoptysis	1	...	...	...	1	...	...	...	2	
Hepatic cong:	1	...	1	...	1	...	1	...	4	
Hepatitis	2	...	1	...	3	...	1	...	7	
C. Hepatitis	...	...	2	...	1	...	...	...	3	
Hypertrophia	1	...	...	...	...	...	...	...	1	
Hysteria	2	...	1	...	...	...	1	...	4	
Impetigo	...	...	...	...	...	...	1	...	1	
Lepra	...	...	1	...	...	...	...	...	1	
Leucorrhœa	...	...	...	...	4	...	...	...	4	
Lumbago	1	...	...	...	1	...	...	...	2	
Lungs, diseased	1	...	1	...	...	...	...	...	2	
Marasmus	1	...	...	...	...	...	...	...	1	
Melancholia	...	...	...	...	1	...	...	...	1	
Menorrhagia	...	...	1	...	2	...	3	...	6	
Neuralgia	...	...	...	...	...	...	1	...	1	
Palpitatio	2	...	...	...	1	...	3	...	6	
Paraplegia	...	...	1	...	...	...	...	...	1	
Pericarditis	1	...	...	...	...	...	...	...	1	
Phthisis	...	...	...	...	5	...	...	...	5	
Piles	...	...	...	...	1	...	...	...	1	
Pleuritis	2	...	1	...	1	...	...	...	4	
Pneumonia	2	...	...	...	1	...	1	...	4	
C. Pneumonia	...	...	...	...	2	...	1	...	3	
Porrigo	1	...	...	...	...	...	...	...	1	
Pseudosyphilis	...	...	...	...	...	...	1	...	1	
Psoriasis	2	...	1	...	1	...	1	...	5	
Rheumatismus	...	...	1	...	3	...	...	...	4	
C. Rheumatismus	...	...	...	...	1	...	...	...	1	
Sciatica	1	...	...	...	...	...	...	...	1	
Stomach, diseased	...	...	1	...	...	...	...	...	1	
Spasm	2	...	...	...	...	...	...	...	2	
Struma	...	...	...	...	1	...	...	...	1	
Syphilis	...	...	...	...	1	...	1	...	2	
Tracheitis	1	...	...	...	...	...	...	...	1	
Chronic Tracheitis	1	...	...	...	...	...	...	...	1	
Uterine disease	1	...	...	...	2	...	...	...	3	
Vertigo	...	...	...	...	1	...	3	...	4	
Total	69	...	30	...	72	...	42	...	213	...

Figure 4: Out-cases reported by Charles Hastings at the Worcester Royal Infirmary (Hastings 1841)

go to next page

Hastings' report also informs us that adult women and men were treated in approximately equal numbers but that 86.7% of the sub-adult in-cases (less than 20 years of age) were female (Fig 5). Since 1792, women had been allowed to subscribe to the hospital for treatment (WRINL 2002). Overall, of the 189 in-patients attended by Hastings, 84.1% were adult and 15.9% were sub-adult.

	MALES.				FEMALES.			
	Under 20 yrs.		Above 20 yrs.		Under 20 yrs.		Above 20 yrs.	
	Cases.	Died.	Cases.	Died.	Cases.	Died.	Cases.	Died.
January	3	...	8	1	5	...	11	
February	...	...	4	...	2	...	5	
March	...	...	10	...	1	...	6	
April	...	...	2	...	1	...	. 3	
May	1	...	12	2	1	...	10	
June	...	...	4	...	...	...	7	
July	...	...	5	...	2	...	9	
August	...	...	2	...	...	...	6	
September......	...	...	9	1	6	...	10	2
October	...	...	2	...	1	...	5	
November ..	...	...	11	...	6	1	12	
December	...	...	2	...	1	...	4	
Total	4	...	71	4	26	1	88	2

	TOTAL MALES.		TOTAL FEMALES.		OF BOTH SEXES.	
	Cases.	Died.	Cases.	Died.	Cases.	Died.
January	9	1	15	...	24	1
February	4	...	7	...	11	
March	9	...	5	...	14	
April	1	...	5	...	6	
May	11	2	12	2	23	4
June	1	...	7	...	8	
July	10	...	11	...	21	
August	2	...	6	...	8	
September	11	1	16	...	27	1
October	3	...	9	...	12	
November	13	...	16	1	29	1
December.................	1	...	5	...	6	
Total	75	4	114	3	189	7

Figure 5: Summary of cases reported by age and sex (Hastings 1841)

It is clear that Hastings had a specialist interest in understanding the disease prevalence according to occupation, seasonality, age and sex. In his report, he considers that rheumatism and dropsy are more common in navigators, boatmen and out-door labourers, whilst dyspepsia, gastrodynia and hepatic affections are more frequent in those connected with the local glove manufacturing trade. It is well documented that Hastings took a specific interest in chest and other diseases amongst leather dressers, glovers, needlepointers, china workers and stone cutters, who were involved in the leading trades in post-medieval Worcester, peaking in number in the 1820s (Bartrip 2003; McMenemey 1959). Subsequently, Thomas Arlidge, another physician investigating the effects of the environment of potteries on health in Stoke-upon-Trent, concluded that the most prevalent conditions amongst male workers were bronchitis, phthisis (tuberculosis), rheumatic afflictions, stomach disorders and lead poisoning; for women, the most common complaints were stomach disorders, uterine maladies, phthisis (tuberculosis), anaemia, bronchitis and lead poisoning (Bartrip 2003). The main cause of this apparent high prevalence of pulmonary diseases was the inhalation of dust containing silica (Hicks 2006). Epidemiological research carried out by contemporary physicians such as Arlidge and Hastings eventually culminated in the recognition of the role of occupation in disease aetiology and improvements of conditions in the workplace, reflected by the introduction of parliamentary legislation starting with the Factory Act 1844 (Bartrip 2003). Hastings proved to be a leading figure in the direction of health care and research at the hospital, until his retirement from the General Medical Council in 1863, and took an active interest in the influence of poor housing and sanitary conditions on health, given the many outbreaks of cholera in Worcester during the Victorian period (Worcester City Council 2006), as well as in poor-law medical relief, the establishment of recognised professional medical practices and authoritative bodies in addition to studies of morbid anatomy (McMenemey 1947).

Other sources indicate that Hastings was directly involved in surgical procedures and was described by the leading surgeon Wilson Philip as being extremely adept in practice, ‘his expertness in dissection was often of great use when it was necessary to be expeditious and to lose as little blood as possible’ (McMenemey 1947, after Mercian Archaeology 2005). It is evident that his skill in amputation was highly valued and this was a practice carried out on a regular basis at the Infirmary. Indeed, McMenemey (1947, 153) states that the Infirmary began to make provisions for wooden legs in 1809. The detailed descriptions Hastings (1841, 343–4) gives us of his cases informs us that thorough physical examinations of the mouth (tongue), chest, abdomen, bowels, skin and pulse were all thoroughly made. Hastings reportedly first used a stethoscope in 1820 (McMenemey 1959, 44). Treatments appear to be rather primitive and consisted of the administration of medicines such as spirit of nitrous aether, camphor mixture, saline antimonial mixture, port wine, carbonate of soda, mercury with chalk, compound chalk powder, calomel and opium. In addition, blood-letting was also practised; heads were shaved and cupped, and leaches were used. The descriptions of the post-mortems provided confirm that they were carried out between 18 and 48 hours after death and that craniotomies as well as examinations of the thorax were undertaken although in some cases only craniotomy was carried out (Hastings 1841, 343–4).

The physical evidence

Methods and process

The skeletal material was analysed according to the standards laid out in the guidelines recommended by the British Association of Biological Anthropologists and Osteologists in conjunction with the IFA (Guidelines to the Standards for Recording Human Remains, Brickley and McKinley 2004) as well as by English Heritage (Human Bones from Archaeological Sites: Guidelines for producing assessment documents and analytical reports, Centre for Archaeology Guidelines, 2002).

Recording of the material was carried out using the recognised descriptions contained in *Standards for data collection from human skeletal remains* by Buikstra and Ubelaker (1994). The database has been included in the site archive.

- The material was analysed macroscopically and where necessary with the aid of a magnifying glass for identification purposes. Where relevant, digital photographs have been used for illustration and a full digital image archive of all pathologies and any other features of interest has been provided.
- The material was analysed without prior knowledge of associated artefacts so that the assessment remained as objective as possible.
- Radiographs were taken at 70kv for 42 seconds.

Each element recorded was given a unique identification number (ID****) and recorded by context. In each instance, the identification, side and portion of the bone was noted, along with completeness, taphonomy and observable joint surfaces.

Reasons for the analysis

Osteological analysis was carried out to ascertain:

- Condition of bone present.
- Completeness of the skeleton.
- Inventory of the skeletal material.
- Sex determination.
- Age assessment.
- Non-metric traits.
- Stature.
- Skeletal pathology.
- Dental pathology.

Any metrics that would provide an estimation of sex or of stature were taken where possible (Bass 1995). The pelvic or skull bones were also analysed for sexually dimorphic traits where preservation allowed, using the criteria set out by Buikstra and Ubelaker (1994). Age determination was carried out using epiphyseal fusion (Scheuer and Black 2004), analysis of the pubic symphysis and of the auricular surface, where appropriate, and classified according to Brookes and Suchey (1990) and Lovejoy *et al* (1985). Dental attrition was recorded but not used to provide an age estimate due to the consistent problems experienced with the application of this technique to populations of this period (Brickley *et al* 2006).

A total of 1365 identifiable fragments were analysed for the purposes of the demographic study. An additional 463 fragments of unsided mid-rib shaft, unidentifiable long bones and skull bone fragments were also scanned for pathology and peri-mortem modifications, making the total number of observable fragments for pathology and peri-mortem modifications 1828.

Preservation of material

The condition of the skeletal material was analysed macroscopically assessed and graded according to those guidelines set out by Brickley and McKinley (2004). Since most of the skeletons exhibited more than one grade of state of preservation, these categories were simplified into four main groups of preservation: Good (grades 0–2), Fair (grades 2–4), Poor (grades 4–5). Factors extrinsic (such as soil acidity or hydrolic action) and intrinsic (shape and density) to the bone can contribute to its preservation; it has been reported that age of the individual can also be an underlying contributory factor to state of preservation of skeletal material, with older and younger individuals more likely to have less robust and more susceptible bones (Henderson 1987).

As illustrated in Figure 6, overall 86.6% of the fragments were observed to be in ‘good’ condition and 12.5% were categorised as being of ‘fair’ condition. This indicates that any traces post-mortem modifications or pathological changes should be readily observable. Closer examination revealed that this pattern of preservation was reflected in all contexts. The majority of fragments from each context were of good preservation: 5001 (82.5% ‘good’ preservation), 5003 (86.9%), 5008 (73.3%) and 10003 (88.7%).

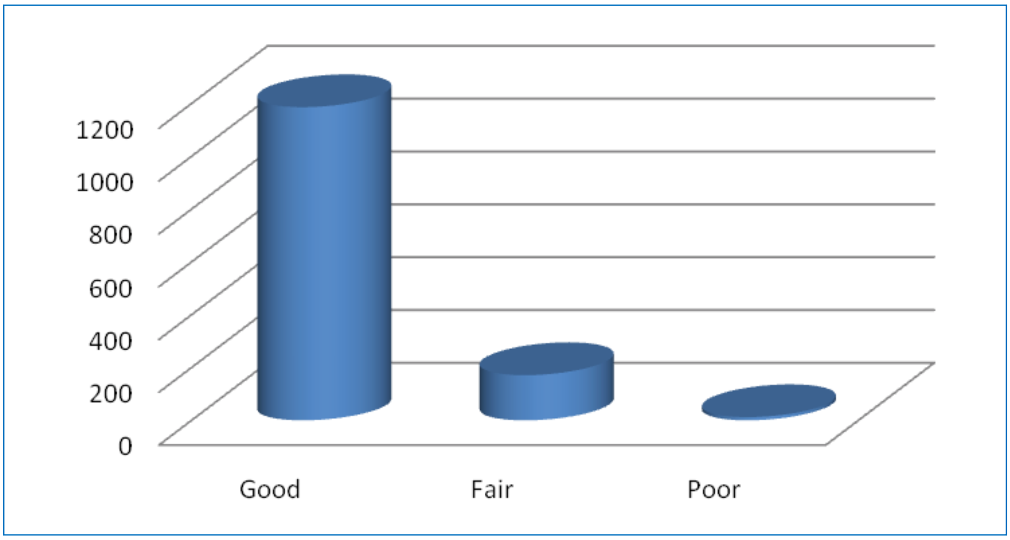

Figure 6: Preservation of the disarticulated skeletal remains

to previous view

In addition, overall, 97% of fragments analysed were categorised as having 75–100% of their cortical bone observable, indicating that the bone surface on the majority of elements was intact and evidence of peri-mortem modifications would be well preserved.

Comparison of the numbers of different elements represented in the assemblage from the Infirmary compared to those of St Andrew's, Worcester (a contemporary disarticulated skeletal assemblage from a parish churchyard) indicates that there was no preservation bias between the two samples (Fig 7). Statistical analysis using Spearman's rank test indicates an extremely significant statistical correlation between the two assemblages ($r = 0.9273$, $p = 0.0003$) and, therefore, there appears to be no significant absence of any particular elements.

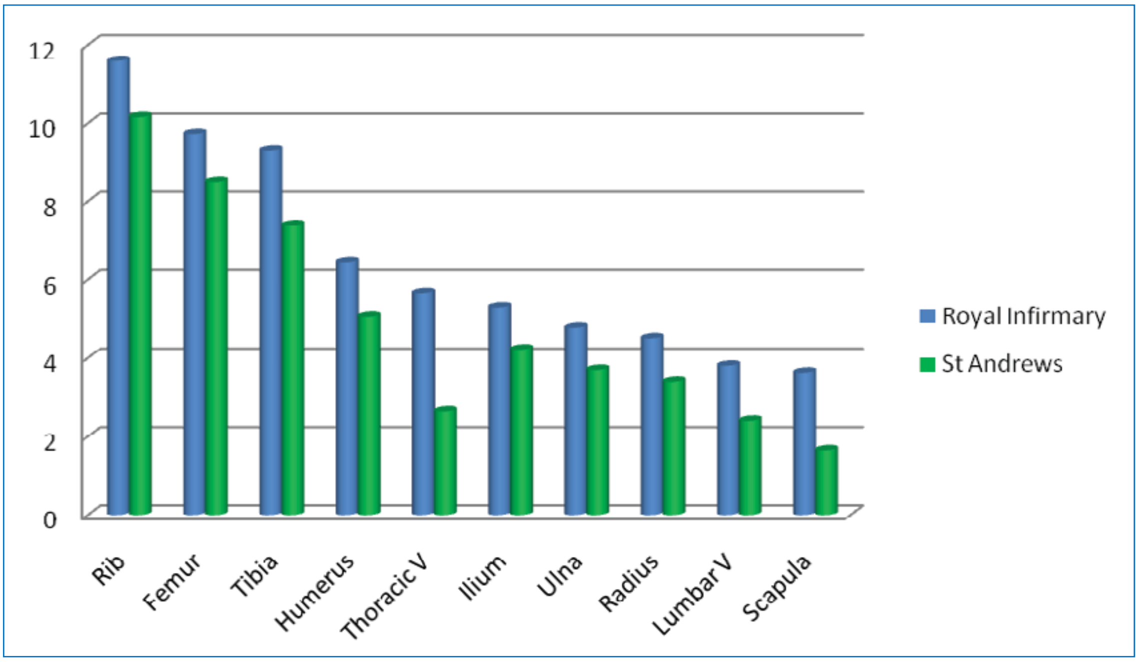

Figure 7: Comparison of elements present at Worcester Royal Infirmary in relation to the disarticulated assemblage from St Andrew's, Worcester (NISP)

Completeness of elements

Completeness of elements is another useful indicator of how much potential data may be collated from the bones, particularly based upon metric analysis. Disarticulated elements are categorised as being <25%, 25–50%, 50–75% or 75%> complete.

Recording of the completeness of elements can allow an insight to be gained into how much post-depositional activity has occurred as well as providing an assessment as to how much information can potentially be gained from the remains.

A large proportion of the elements (42.7%) from the Worcester Infirmary assemblage elements were less than 25% complete (Fig 8), indicating that data based on metric analysis may be restricted. However, over half of the elements under analysis were over 25% complete and this indicates that, overall, that the assemblage still offered substantial potential for obtaining data.

go to next page

to previous view

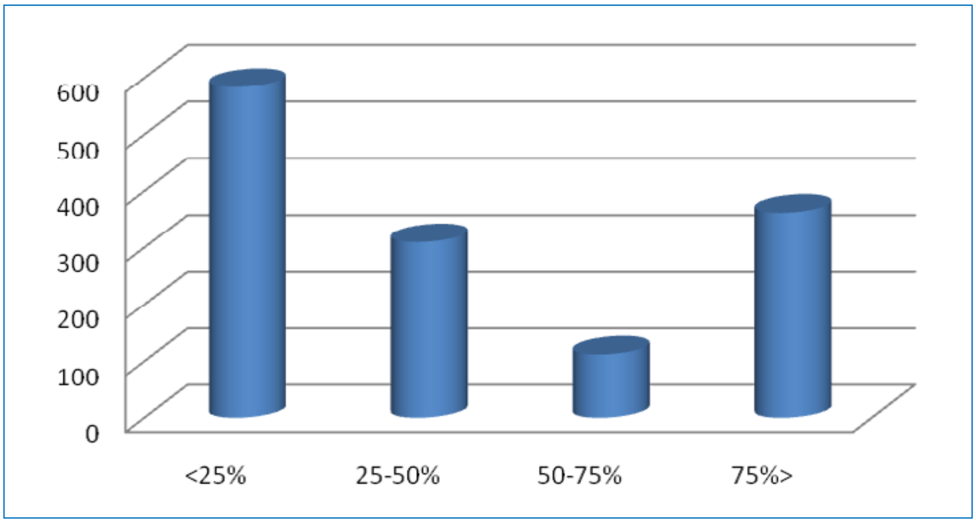

Figure 8: Completeness of disarticulated skeletal elements

Minimum number of individuals

A total of 1365 human skeletal fragments of disarticulated remains were subject to demographic analysis. The minimum number of individuals (MNI) represented by the assemblage is calculated from the number of repeated skeletal elements within the sample taking age into account. It can also be important to consider the context of the skeletal elements, since one context should represent a single event of deposition of skeletal material. In this case, it could be argued that elements recovered from different contexts are likely to belong to different individuals. Here, 5003, 5001, 5008 and 10003 are presented as separate depositional events.

For comparative purposes, the MNI has been estimated by context as well as for the whole assemblage (Table 1).

The estimated of minimum numbers of individuals calculated by context are likely to be more accurate than the collated assemblage estimate due to the distinct nature of the features. However, it should be noted that context 5001 represented a disturbed context.

Context	MNI by contex	MNI collated assemblage
5003	13	
5001	7	
5008	4	
10003	3	
Total	***27***	***19***

Table 1: Estimated minimum number of individuals, calculated by context and from the collated assemblage

go to next page

to previous view

Demographic data

For the purposes of age assessment, each element was examined for evidence of epiphyseal fusion and categorised as following:

- Foetal = <36 weeks.
- Neonate = 0–1 month.
- Infant = 1–12 months.
- Young Child = 1–3 years.
- Older Child = 4–7 years.
- Juvenile = 8–12 years.
- Adolescent = 13–19 years.
- Young Adult = 20–34 years.
- Middle Adult = 35–49 years.
- Old Adult = 50+ years.

The results of the age assessment, whether calculated by context or from the collated data, indicate that a much greater proportion of the sample is adult (70.4% c, 70% cd) and reflects the demographic data observed from the historical records discussed earlier (Table 2).

Age group	MNI by context (c)	MNI collated data (cd)
Adult MNI	19	14
Foetal MNI	0	0
Neonate MNI	2	1
Infant MNI	1	1
Young child MNI	1	1
Older child MNI	0	0
Juvenile MNI	2	2
Adolescent MNI	1	1
Sub-adult MNI (10003)	1	0
Total	***27***	***20***

Table 2: Minimum number of individuals by age

go to next page

to previous view

Nonetheless, in comparison to other skeletal populations from contemporary hospitals, anatomical schools and medical institutions, the Worcester Infirmary assemblage actually contains one of the highest proportions of sub-adult and adult elements (Fig 9).

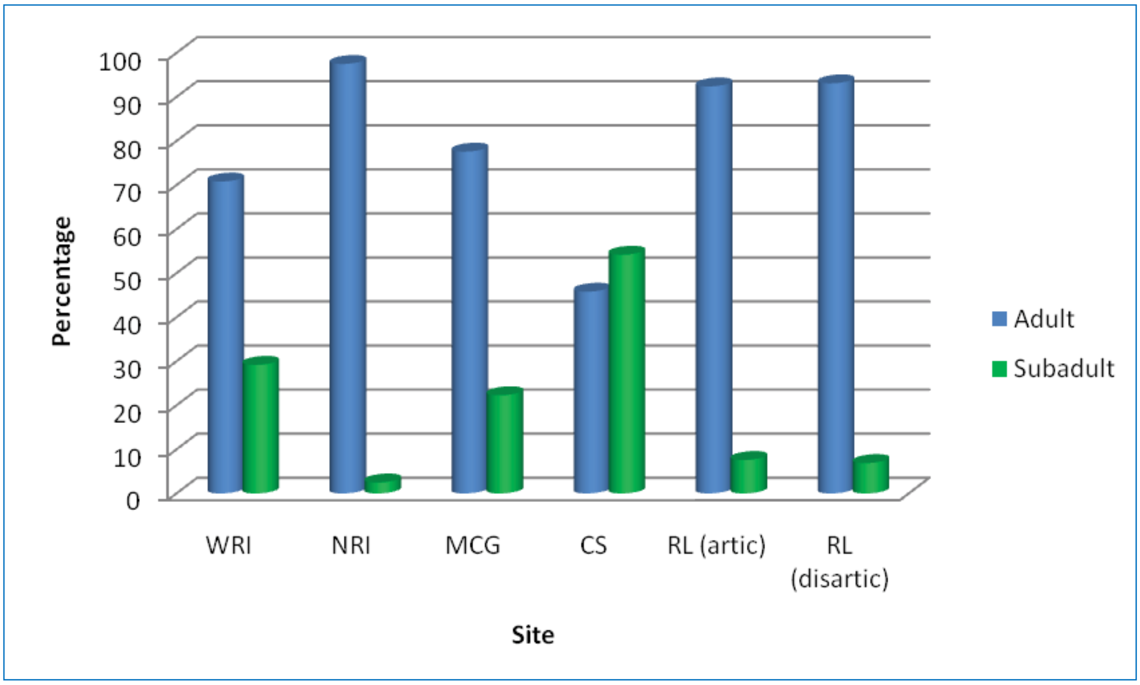

Figure 9: Comparison of age distributions from 19th century hospital populations (MNE). Key; WRI Worcester Royal Infirmary, NRI Newcastle Royal Infirmary, MCG Medical College of Georgia, CSAS Craven Street Anatomy School, RLH Royal London Hospital

It was possible to carry out sex estimation for 58 elements, only 4.3% of the total assemblage. This reflects the fragmentation of the assemblage, both from post-depositional damage and also post-mortem modifications, which will be discussed later. Due to the small size of the sample, data was only analysed at the level of the whole assemblage.

Sex	N =	%
Male/possible M	42	72.4
Female/possible F	16	27.6
Total	***58***	***100.0***

Table 3: Number of individuals by sex

As indicated by Table 3, it is clear that there is a significantly higher number of observable males than females in the assemblage. A similar bias towards males was found in both the disarticulated and articulated assemblages from the contemporary Royal London Hospital, Whitechapel (Fig 10). Here, of those elements and skeletons that could be assessed for sex, 81.8% were male amongst the disarticulated assemblage and 71.5% were male from the articulated assemblage (Powers 2009). At the Newcastle Royal Infirmary, of those articulated individuals for whom sex could be estimated, 67.4% were male whilst 32.6% were female (Boulter *et al* 1998, 43). Analysis of skeletal assemblages may reveal a moderate bias towards male individuals, thought to be associated with better preservation of more rugous skeletal elements. However, a bias towards male elements to the extent revealed in the Infirmary assemblage was not found in the disarticulated assemblage from the churchyard of

go to next page

to previous view

St Andrew's, where the male:female ratio was 0.57:0.43 (Western 2006) nor in the analysis of St Martin's-in-the-Bull Ring, Birmingham (0.58:0.42 m:f; Brickley *et al* 2006). Similarly, Powers (2009) observes that contemporary cemetery sites from London yield lower ratios of male:female individuals than recorded at the Royal London Hospital.

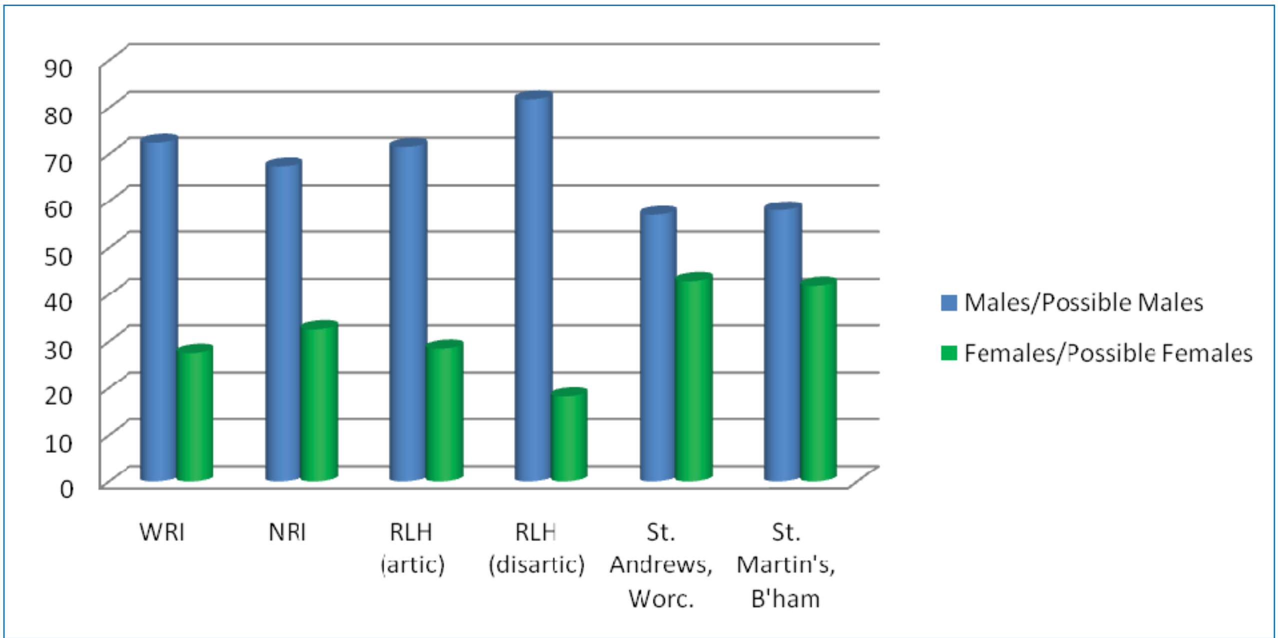

Figure 10: Comparison of male to female composition of skeletal assemblages (MNE).
Key; WRI Worcester Royal Infirmary, NRI Newcastle Royal Infirmary, RLH Royal London Hospital

Unfortunately, the sample size of elements that could be assessed for both age and sex is too small to draw any conclusions from (Table 4).

Sex	Very young adult	Young adult	Middle adult	Old adult
Male	0	2	3	0
Female	0	2	0	1

Table 4: Demographic data of disarticulated sample

Stature

Stature was assessed according to the metric analysis of long bones of adults using the formula provided by Trotter (1970). Only three elements (ID 1098, 1366 and 1368), were available for length assessment. Stature was assessed as being 1.71m, 1.72m and 1.72m respectively (+/- 3cm). All the elements were observed to be male.

Skeletal pathology

Only TPRs (True Prevalence Rates: based upon prevalence of disease per observable element/part thereof) can be calculated for the pathology prevalence in disarticulated skeletal material. Whilst this allows for inter-site comparison of pathology prevalence rates from both articulated and disarticulated assemblages, for the most part the age and sex of the individual is not known and the distribution of lesions about the body cannot be assessed due to the disarticulated nature of the assemblage. The diagnosis of specific diseases in many cases

go to next page

to previous view

will, therefore, not be possible and no pattern of prevalence amongst different age or sex groups can be analysed. Nonetheless, the recording of those diseases that can be identified confirms their presence from the directly observable physical evidence, rather than having to rely on speculative historical documents where clinical knowledge was rapidly changing and medical terminology was not uniform. Another limitation to the analysis is the size of the assemblage when it is broken down into individual contexts. Since contexts 5001 and 5008 are individually too small to form the basis of any meaningful analysis, the data presented here is based upon the whole assemblage, totalling 1828 fragments.

Overall, of the 577 fragments of identifiable adult bone, 18.5% showed pathological changes (n = 107). Of the 94 sub-adult fragments, 8.5% exhibited pathology (n = 8). The difference is likely to be explained by adults living longer, allowing pathological conditions to affect the skeleton, as younger individuals succumbed more quickly to particularly perilous epidemic and endemic diseases.

The comparative rates of pathologies by aetiology, shown in Figure 11, indicate that the assemblage from the Worcester Royal Infirmary is particularly high in levels of inflammation, which can be associated both with infection or soft tissue trauma. This is particularly evident when comparing the relative rates of disease by type with the data from the contemporary disarticulated assemblage from nearby St Andrew's churchyard (Western 2006). Whilst evidence of trauma is the same in the two assemblages, joint disease prevalence is much lower and inflammation is much higher at the Worcester Royal Infirmary.

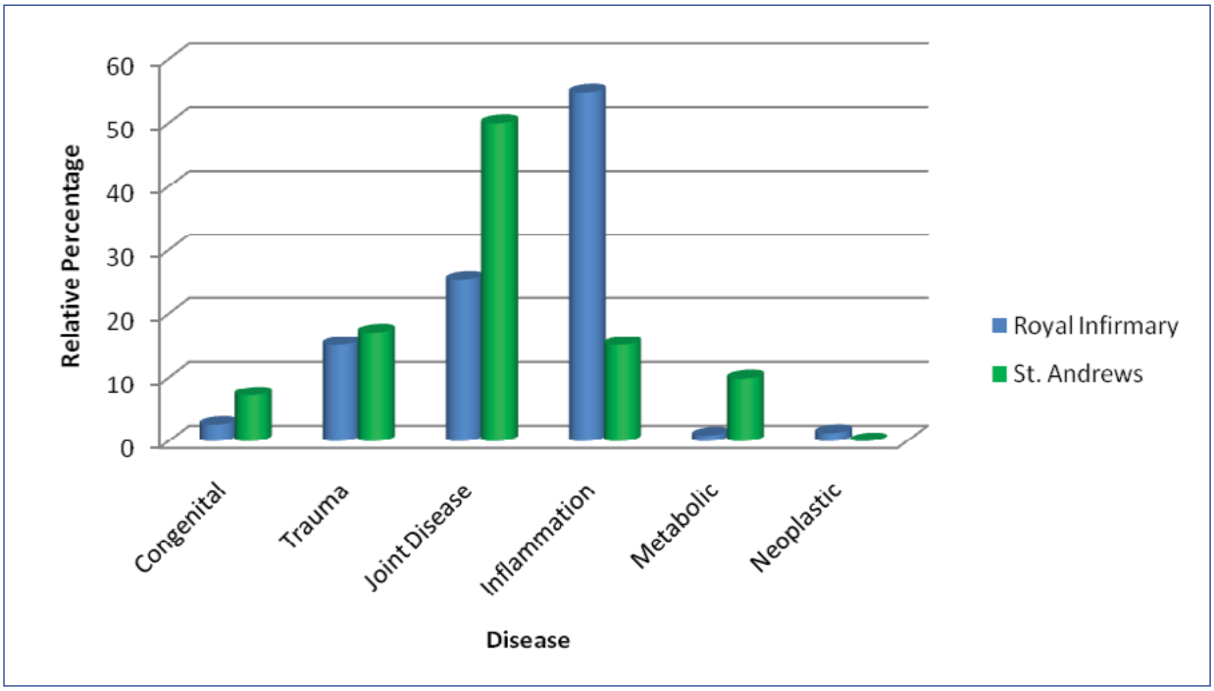

Figure 11: Comparative rates of relative pathology prevalence according to aetiology (number of identified specimens, NISP)

go to next page

Congenital conditions

Only a small number of congenital conditions were observed (Table 5). Two cases of lateral wedging of vertebral bodies or arches (ID 663 and 692) were recorded, indicating that scoliosis was present amongst the population. Scoliosis usually occurs as a developmental condition, manifesting itself during adolescence. However, it can also be associated with congenital issues concerning the delayed development of the cartilagenous vertebral centra (Barnes 1994). Severe scoliosis can have serious consequences on the functioning of internal organs. The main sequela of milder scoliosis is the result of uneven pressure being placed on the individual vertebra, which can lead to degenerative joint disease and osteoarthritis (Salter 1999). This is testified to by the presence of a large enthesophyte on one of the vertebral bodies observed here. It is also likely that the malformation of the rib head (ID 227) would have been associated with a scoliosis of the spine.

Pathology	No	Total no elements	TPR (%)
Scolisis	2	189	1.1
Calcaneo-navicular coalition bar	1	22	4.5
Congenital foot malformation	1	20	5.0
Rib malformation	1	183	0.5
Spondylolysis	1	52	1.9

Table 5: Summary of congenital conditions (TPR – true prevalence rate)

The presence of a partial calcaneo-navicular bar was indicated by an expanded pseudoarthrosis on the medial side of a calcaneus (ID 995). This is a painful condition leading to restriction in the flexibility and movement of the foot and invariably pain from secondary degenerative joint disease (Salter 1999).

Also present was a malformed left talus (ID 1083). The superior articular surface was flatter and rather than forming a rounded convex surface for articulation with the talus, actually turns up (superiorly) at the distal end (Plate 5). Thus, the ankle joint would have been quite rigid. Since only one bone was observable, it is difficult to ascertain the formation of the whole foot but it is likely this represents a congenital foot malformation such as talipes equinovarus (clubfoot).

One case of spondylolysis was observed (ID 630), where a developmental weakness in the vertebral arch leads to a separation of the posterior arch (*pars interarticularis*) from the vertebral body if the vertebra is subsequently exposed to trauma (Salter 1999, 372). The instability experienced in the spine caused as a result of this defect was observed by the presence of secondary osteoarthritis of the vertebral body.

to previous view

Plate 5: Malformed talus (ID 1083; normal on left for comparison)

Metabolic conditions

Only two metabolic disorders were observed; one was a case of healed rickets (*n* = 1, 0.9%), where a tibia exhibited antero-lateral bowing in the proximal third (ID 60). Rickets is the result of a lack of vitamin D during childhood and has been observed to have a higher rate in post-medieval skeletal populations (Roberts and Cox 2003). Examples have been found in both the Worcester St Andrew's churchyard (Western 2006) as well as in the contemporary St Martin's population from nearby Birmingham (Brickley *et al* 2006). Cribra orbitalia, an indicator of megaloblastic or haemolytic anaemia, was also observed in one eye orbit roof (ID 724). It is often found in higher prevalence rates in hospital populations (Roberts and Cox 2003). Unfortunately, only two orbits were observable and, thus, no inferences regarding prevalence of cribra orbitalia in the population from the Worcester Royal Infirmary could be made.

Inflammatory conditions

As illustrated in Figure 4, inflammatory conditions were the most prevalent type of pathology found in the assemblage, with 55.6% of all pathologies recorded resulting from inflammation. A total of 127 fragments were observed to exhibit inflammatory lesions (7.0%). The vast majority of these lesions were non-specific; 80% of the inflammatory lesions were recorded as periostitis (inflammation to the periosteum covering the surface of the bone) and 10.2% were recorded as osteitis an inflammatory response starting within the compact bone, involving the cortex and surface of the bone; Plate 6). Osteomyelitis (a suppurative infection arising within the marrow spaces of the bone) is only diagnosed if there is the presence of an observable cloaca. Ninety percent of cases of osteomyelitis involved the *Staphylococcus* *aureus* bacteria (Ortner 2003). Although no cloacae were observed here and, therefore, no cases of osteomyelitis were recorded, it is likely that observability may have been compromised by the fragmentation of the assemblage. Alternative diagnoses of conditions such as hypertrophic pulmonary osteoarthropathy, where neurocirculatory mechanisms lead to pronounced and extensive expansion of the bone, particularly in the tibiae and fibulae, should also be considered (Ortner 2003, 354). The most common elements exhibiting non-specific lesions are listed in Table 6 below.

Plate 6: Non-specific infection of the femur (ID 790; normal on left for comparison)

Element	No	Total no of elements	TPR %
Tibia	34	110	30.9
Rib	44	581	7.5
Fibula	13	65	20.0
Femur	9	114	7.9
Radius	5	54	9.3
Ulna	4	57	7.0
Humerus	4	77	5.2
Clavicle	2	25	8.0
Ilium	2	61	3.3

Table 6: Summary of inflammatory conditions (non-specific; TPR – true prevalence rate)

to previous view

It is clear that the bones of the lower leg (tibia and fibula) were associated with a very high rate of inflammation. This is likely to represent the predilection of the lower leg to be involved in soft tissue trauma and infection. The pathology observed in these elements may well reflect the 'inflamed legs' mentioned by Hastings (1841, 342). So great was the incidence of ulcerated legs at the Infirmary that in 1818, two attics were fitted up with ten beds as a septic ward so that these patients could be treated separately (McMenemey 1959, 38).

Plate 7: Large resorbed bone lesions in os coxa (ID 158)

In addition to these non-specific inflammatory lesions, there were two possible cases of tuberculosis of the hip joint (*n* = 2, 11.1%). The tuberculosis of the hip joint is represented by a massively resorbed fragment of ilium/pubis (ID 158) with rounded lytic lesions representing draining abscesses (Plate 7). Whilst tuberculosis is often reported to affect the hip joint and the changes observed are typical of those caused by this disease, a differential diagnosis of brucellosis or possibly mycotic infection cannot be ruled out. This is also true of a second fragment (ID 785), a proximal femur fragment, with a large lytic lesion in the greater trochanter (Plate 33). The lesion has well defined, sclerotic edges with two small bony spurs crossing into the lesion at the mid-point, indicating that the lesion was likely to have been two smaller lesions that have coalesced as one. Some striated and porotic lamellar bone periostitis was located on the adjacent anterior surface indicating inflammation to the region as a whole. However, the joint surface itself was not affected. Similar lesions have been noted by Ortner (2003) to occur in chronic tuberculosis of the hip as well as being a result of brucellosis, echinococcus, cancer and mycotic infections. Unfortunately, it is difficult to differentiate between these conditions in disarticulated material where the distribution of the lesions about the body cannot be analysed. Direct evidence of skeletal involvement of tuberculosis (not including rib lesions) has been observed to vary between 0.21 and 0.75% CPR in cemetery populations and is slightly higher at 1.06% CPR at the Newcastle Infirmary (Roberts and Cox 2003, 339).

Rib lesions were observed in 7.5% (TPR) of the rib fragments present. These are generally associated with inflammation of the pleura and although they are non-specific they can be related to tuberculosis (Roberts *et al* 1998, Roberts and Manchester 1997, Mays *et al* 2002). The cases of 'diseased lung' and 'pleuritis' observed by Hastings (1841, 342) may well

go to next page

to previous view

have lead to this skeletal response. It is interesting to note that the rate of rib lesions in the Infirmary assemblage is higher than that of St Andrew's, Worcester, where a TPR rate of 2.9% was recorded (Western 2006). A 4.76% CPR of rib lesions was noted at Newcastle Infirmary (Roberts and Cox 2003, 339) and the CPR at St Martin's-in-the-Bull Ring was recorded as 8.5% (Brickley *et al* 2006).

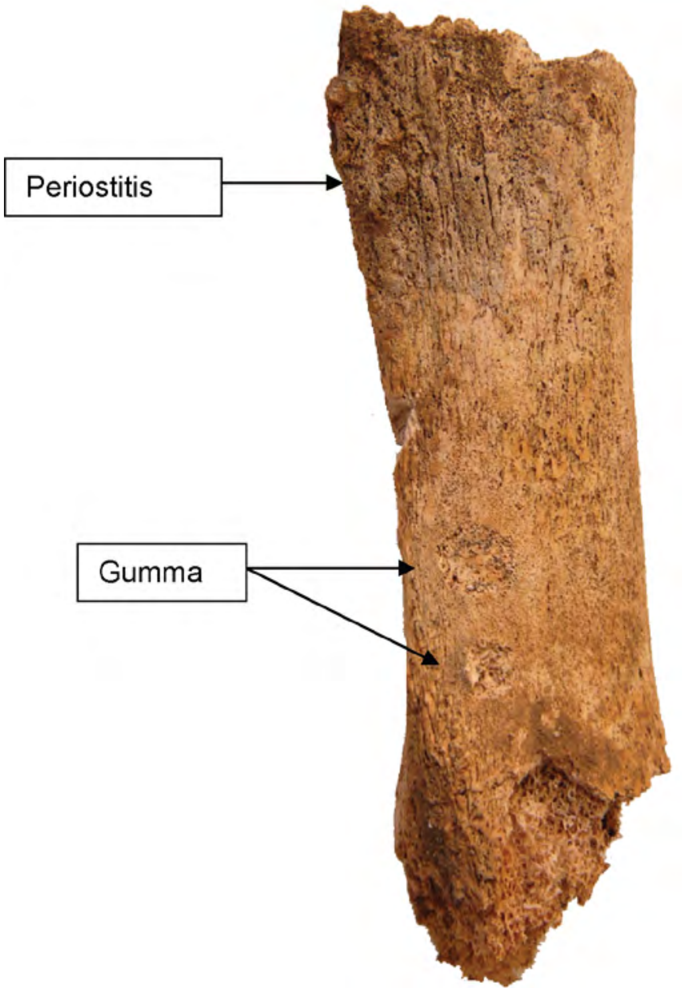

Plate 8: Extensive periostitis and gumma indicative of syphilis, tibia (ID 40)

Five fragments exhibited changes that are likely to have been associated with treponemal disease, more specifically venereal syphilis. Three tibiae showed changes consistent with syphilitic infection (*n* = 3, 2.7%). One fragment (ID 40) had a grossly enlarged cortex in addition to heavy periostitic deposits (porotic woven bone, so active at time of death). The whole diaphysis of the fragment appeared enlarged. On the medial aspect, two well defined lytic lesions (gumma) were observed amid porotic woven bone periostitis (Plate 8). Another tibia (ID 898) was found to have extensive deposit of porotic woven bone on the anterior diaphysis, giving the diaphysis a swollen appearance and also making the bone appear bowed to the anterior in the distal half. Anterior cortex of the diaphysis was, therefore, much thicker. Bowing in the distal half of the anterior of the tibia is found commonly in syphilis and is known as 'sabre shin' (Aufderheide and Rodriguez-Martin 1998). It is very likely that this tibia represents a second case of syphilis. A third tibia (ID 901) showing extensive periostitic remodelling exhibited a defined margin to the remodelling as well as lytic lesions in the midshaft (Plate 9). The localised nature of the lesion as well as the presence of lytic

go to next page

remodelling indicates that syphilis may have been responsible for these changes to the bone. Unfortunately, this element had been damaged post-mortem at the site of the lesion, so that the full extent of the lesion could not be ascertained. The well-defined nature of the lesion may indicate that a leg ulcer could have been the cause of the pathological changes, although these tend not to demonstrate lysis unless associated with specific infection such as mycetoma (AufderHeide and Rodriguez-Martin 1998, 223).

Plate 9: Large well defined area of periostitis and resorption possibly representing syphilis or an infected leg ulcer (ID 901)

In addition to the tibiae, one manubrium (ID 298) was found to have diffuse woven bone periostitis covering the majority of the surface in association with two lytic lesion in the sterno-manubrium joint surface (*n* = 1, 10%). Comparable changes of the manubrium have been found in articulated skeletons demonstrating diagnostic syphilitic lesions and also in those with tuberculosis (Ortner 2003). One femur (ID 804) also exhibited extensive striated, spiculated and porotic mixed lamellar and woven bone periositis and remodelling in the distal third all around the shaft (n = 1, 0.9%). One gumma was observed amid the periostitic deposit. Interestingly, no cases of syphilis were observed at St Andrew's (Western 2006) or the cemetery at St Martin's-in-the-Bull Ring (Brickley *et al* 2001). Boulter *et al* (1998) report a higher crude prevalence rate of syphilis at the Newcastle Infirmary (3.7%) than at other contemporary cemeteries where rates vary between 0.28 and 1.13% CPR (Roberts and Cox 2003).

to previous view

Plate 10: Septic arthritis (patella ID 857)

Additionally, one probable case of septic arthritis of the knee was recorded (n = 1, 2.3%). The patella (ID 857) presented with massive lamellar bone deposits on the anterior surface with lysis of the posterior surface (Plate 10). The combination of bone resorption and bone deposition at the joint is generally indicative of septic arthritis, a condition that is particularly prevalent at the knee joint which is particularly vulnerable to injury.

Trauma	No	Total number of elements	TPR %
Osteochondritis dissecans – femur	2	44	4.5
Osteochondritis dissecans – humerus	1	24	4.2
Femur fracture – peri-mortem	3	81	3.7
Fracture humerus – peri-mortem	1	58	1.7
Fracture radius – peri-mortem	1	48	2.8
Fracture talus intra-articular	1	20	5.0
Fracture hip intra-articular	1	16	6.3
Fracture radius – colles	2	26	7.7
Fracture rib	9	581	1.5
Osgood-Schlatters Disease	1	60	1.7
Probable dislocation – talus	1	20	5.0

Table 7: Summary of observed trauma (TPR – true prevalence rate)

Trauma

A total of 36 examples of trauma were identified in the assemblage (Table 7). The most common evidence of trauma was fracture of the ribs, followed by osteochondritis dissecans (ID 826, 352 and 1302), exhibited by a localised well-demarcated lesion on the convex surfaces of pressure epiphyses (Salter 1999). These lesions are caused by minor traumatic events, most commonly in the distal femur (knee) joint, as was found here. Also observed was a case of Osgood-Schlatters disease (ID 44) arising from the partial avulsion of the tibial tubercle (Plate 11). This usually occurs during development between the ages of 10–15 years and similar to osteochondritis dissecans, is observed clinically to be more common in

go to next page

active boys. It is thought that excessive stress on the patellar tendon from frequent flexion of the quadriceps muscle leads to multiple subacute microfracturing at the tibial tubercle, which leads to a propensity towards major avulsion fracturing in the event of trauma to the knee (Salter 1999). The sex of two of the three fragments demonstrating these changes was unobservable but one case of osteochondritis dissecans was found on a male femur.

Plate 11: Avulsion of the tibial tubercle, also known as Osgood-Schlatter's Disease (ID 44)

Two examples of Colles fractures were also observed (ID 405 and 547), which are the result of a fall onto an outstretched hand. The force from landing on the wrist causes the distal end of the radius to fracture and to be displaced posteriorly. Once healed, this displacement leaves a characteristic raised horizontal bone ridge across the anterior surface of the bone. Colles fractures are prevalent among the elderly, particularly those suffering from underlying osteoporosis (Salter 1999; Vigorita 2008) but due the disarticulated nature of the material, no age at death could be ascribed to these cases.

Two cases of intra-articular fractures were observed. One intra-articular fracture at the lateral tubercle of the talus (ID 853), across the posterio-medial corner of the articulation for the calcaneus was recorded (Plate 12). Some porotic bone remodelling was present, filling the fracture line, indicating that the fracture was fairly recent. This is likely to have been the result of a forceful impaction of the ankle joint and impaction fractures of the ankle joint are commonly associated with landing directly on the feet after a fall (Salter 1999). A second example of an intra-articular fracture was observed in the superior portion of an acetabulum (hip joint; ID 76). The fracture was well healed but associated with secondary osteoarthritis.

Plate 12: Intra-articular fracture present in talus (ID 853; normal on left for comparison)

The vast majority of fractures observed were well healed and unlikely to be the reason for an individual being an in-patient at the Infirmary. However, six instances of possible spiral and presumably comminuted peri-mortem fracture were observed, four in the femur (ID 772, 788, 798 and 1006), one in the distal humerus (ID 1044) and one in the radius (ID 1106). All the fractures presented sharp edges, curvature to the breaks as well as similar colouration to the cortex. Breakaway notches were also present on the five fully observable fracture breaks (Plate 13). These notches are classic indicators of breaks in fresh bone when it still contains high collagen levels.

Plate 13: Peri-mortem fracture of humerus (ID 1044) with breakaway notches within the cortical bone

to previous view

Additionally, the fracture surface of the radius was observed to exhibit a small amount of woven bone periostitis, indicating that the fracture had occurred very shortly before death. One example consists of a spiral fracture to the right knee, which has been clinically observed to be associated with falling from a height directly onto the knee (Salter 1999). Interestingly, one of the femur fragments has been stained, with the dye covering the surfaces of the peri-mortem break. Since none of the peri-mortem fractures exhibited any healing, it can be inferred that they occurred at or around the time of death.

Evidence of peri-mortem trauma is very unusual in cemetery populations so this number of peri-mortem fractures at the Infirmary is noteworthy. Interestingly, one possible case of a peri-mortem fracture was found in St Andrew's Worcester, found in the same individual exhibiting an unhealed trepanation (Western 2006). McMenemey (1947, 175) notes that in 1821, the hospital imposed charges of 7s 6d a week for board and lodging of patients to patients 'who may be brought in from accidents, occasioned by improper or furious driving of public carriages, or vehicles of any description' in a bid to discourage road traffic accidents, which led to a rise in trauma during this period (Roberts and Cox 2003). Cases of unhealed fractures have also been found at the Royal London Hospital, Whitechapel (Powers 2009).

In addition to the numerous fractures, seven examples of soft tissue trauma were recorded (n = 8, 0.4%), observed through the presence of enthesophytes, usually located at or around muscle attachment sites.

Joint disease

Joint disease was the second most common type of pathology present in the population from the Infirmary, with 25.4% of pathologies being recorded in this category. The majority of lesions consisted of Schmorl's nodes found on the thoracic and lumbar vertebral bodies where the nucleus pulposus of the intervertebral disc herniates into the surface of the body (Table 8). These are common lesions in skeletal and modern populations. Clinically, these are of little significance and are associated with the natural aging process (Salter 1999). Most other cases of joint disease consisted of degenerative joint disease although six cases of osteoarthritis were observed, consisting of eburnation, macroporosity and enthesophytes at the joint.

Element	Number	Total number joints observed	TPR %
Cervical vertebra	5	29	17.2
Humerus	1	42	2.4
Femur	1	65	1.5
Ilium	6	16	37.5
Thoracic vertebra	18	101	17.8
Lumbar vertebra	7	52	13.5
Rib	9	93	9.7
Temporal (TMJ)	1	3	33.3
Tibia	2	52	3.8
Ulna	1	37	2.7

Table 8: Summary of degenerative joint diseases/osteoarthritis observed in the disarticulated population (TPR – true prevalence rate)

go to next page

Although the second most common type of disease in the assemblage from the Infirmary, it should be noted that the rates are lower than that found at St Andrew's, particularly in the case of extra-spinal joint disease (Western 2006).

Neoplastic disease

One suspected neoplastic lesion was found on a right tibia (ID 46). This was represented by a bony swelling to the lateral-posterior aspect of diaphysis, medial to the inferior part of the soleal line. A localised lesion was observed that was not well defined on the surface. The surface of the lesion was slightly more porotic but there was no associated periostitic deposit. Examination of the medullary cavity, however, reveals complete expansion of the trabecular bone into the cavity. Some expansion additionally along the length of the diaphysis. The changes observed were thought to be similar to those reported for nonosteogenic fibroma, fibrosarcoma, osteoblastoma like osteosarcoma or intracortical osteosarcoma (Vigorita 2008) but the specimen would require radiographic investigation before any conclusive diagnosis could be drawn.

One further undiagnosed lesion was observed on the anterior crest of the mid-third of a left tibia (ID 1367). The lesion consisted of a smooth lamellar bone outgrowth without a well-defined margin which appeared intra-cortical in origin. Measuring 32mm S-I x 10mm M-L, the lesion could represent a single enchondroma or possible osteoma but again requires radiographic investigation to aid diagnosis.

Dental disease

Only four mandibles and six teeth were available for observation, so the data for dental disease from the Worcester Royal Infirmary is extremely limited (Table 9).

One possible male mandible (ID 1288) contained anterior dentition exhibiting a pipe-smoking groove (Plate 24). This is was a prevalent past-time during the late Georgian and Victorian period and such grooves, formed by habitually gripping onto clay pipes with the teeth, are frequently observed in male dentition sets in contemporary assemblages, such as St Martin's-in-the-Bull Ring (n = 11), St Andrew's, Worcester (n = 2) and Tallow Hill, Worcester (n = 1; Brickley *et al* 2006, 145; Western 2006, 46–7; Ogden 2003, 13).

Disease	Caries	Calculus	Ante-mortem loss	Abscesses	Enamel hypoplasia
Number of teeth/sockets affected (n)	0	4	9	1	0
Observable teeth/sockets (n)	6	6	41	41	6
Prevalence (%)	0	66.7	22.0	2.4	0

Table 9: Dental disease prevalence rates for the adult disarticulated material

Ante-mortem surgical intervention

Interestingly, the assemblage contained one example of successful ante-mortem surgery. One frontal bone (ID 745) exhibited a trepanation (n = 1, TPR = 12.5%) consisting of two adjacent well healed sub-circular holes (Plate 14). Trepanation was a procedure commonly carried out during the post-medieval period to alleviate headaches associated with increased

to previous view

intracranial pressure. Conversely, however, evidence of the procedure is rare in the archaeological record. One individual was found with similar evidence of a healed trepanation from St Martin's-in-the-Bull Ring, Birmingham (n = 1, CPR = 0.2%) as does one individual from the post-medieval assemblage from St Brides crypt, London (n = 1, CPR = 0.4%).

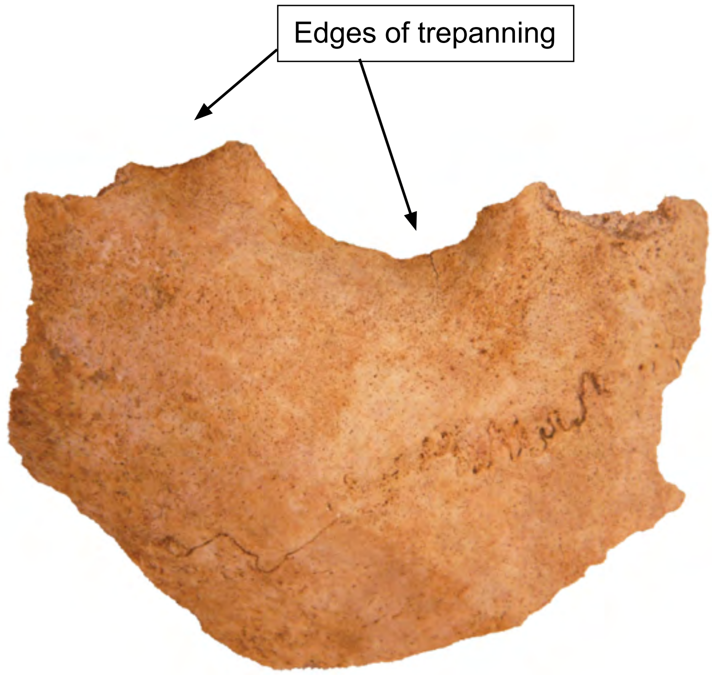

Plate 14: Frontal bone (ID 745) exhibiting the smooth rounded edges of healed trepanation

Miscellaneous

An area of cortical erosion was recorded in the superior sagittal sinus area of an occipital bone (ID 654). A large area of resorption on the endocranial surface was present, obliterating the groove for the superior sagittal sinus (Plate 15). Lacunae created by resorption have been infilled with porotic woven bone, so lesion appears to have been active at the time of death. The area is well demarcated, measuring approximately 3cm x 3cm, although there was no sclerosis of the margins. It is possible that the lesion might have been caused by a sinus aneurysm. Additionally, evidence of craniotomy could also be seen on the fragment.

Similar lesions were observed in what are likely to be associated thoracic vertebrae (ID 1208 and 1209) from context 10003. The erosions of the left lateral aspect of the vertebral body have resulted in a scooped out hollow with flat walled superior and inferior bony ledges formed from the remaining endplates (Plate 16). About a quarter of the body has been lost. Some bony osteoblastic deposition on the anterior body forming a vertical buttress between the superior and inferior endplates is present on the anterior aspect. Similar changes have been reported to be associated with an erosion form of an aortic aneurysm of the descending aorta (Aufderheide and Rodriguez-Martin 1998, 78, Ortner 2003, 356). Aneurysms found here are clinically observed to be arteriosclerotic in aetiology.

go to next page

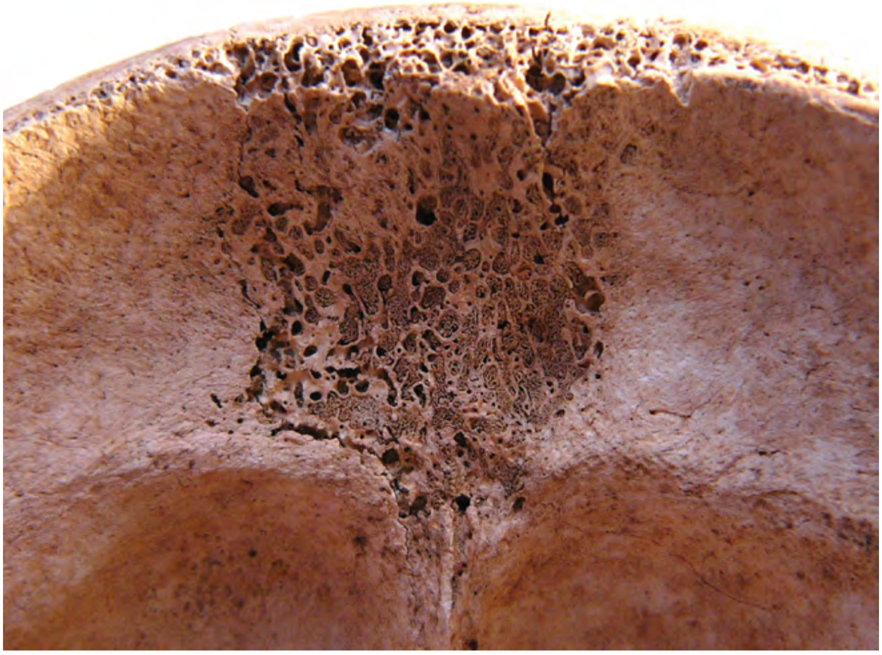

Plate 15: Endocranial erosion of occipital bone (ID 654) with porotic woven bone

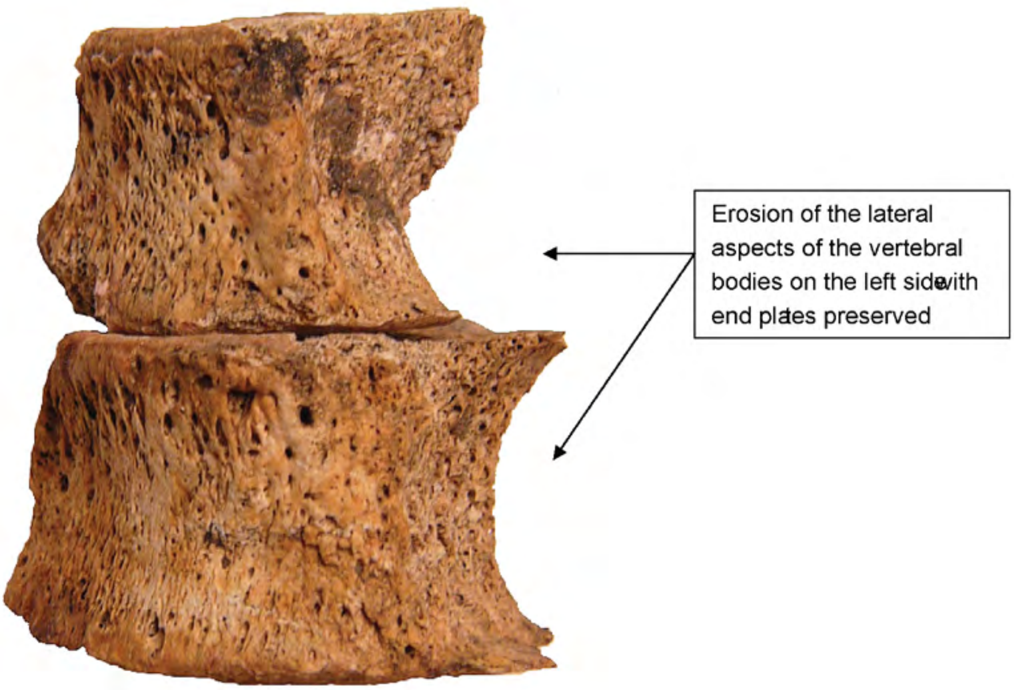

Plate 16: Erosive lesions of thoracic vertebrae likely to indicate the presence of an aortic aneurysm

Also included in the assemblage was a calcified plaque (ID 1127; Plate 17). This large, flat plaque is likely to be either a calcified pericardial or pleural plaque; calcified pericardial plaque occurs in chronic cases of constrictive pericarditis (secondary disorders of the heart), and is most frequently associated with tuberculosis (Roy 2010). Similarly, pleural plaques can be associated with pleural tuberculosis, pleural metastasis, chronic empyema and

to previous view

hemothorax (Medpix 2010). Such plaques are formed when bacteria or other foreign bodies invade healthy tissue; as a result, the immune system responds by creating plaques that may subsequently become calcified, as part of an inflammatory response. They are generally asymptomatic in themselves but their presence can indicate underlying health issues.

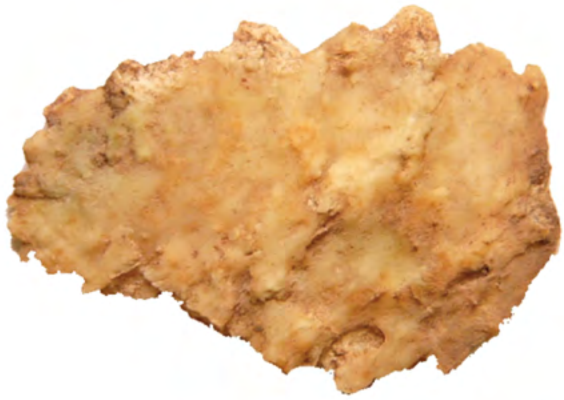

Plate 17: Calcified plaque

Peri- and post-mortem modifications

By Tania Kausmally and Gaynor Western

The following analysis is a discussion of the modifications present on the human skeletal remains from Worcester Royal Infirmary. The human skeletal remains displayed a series of modifications including saw marks, cut marks, knife marks and staining, all of which could be the results of medical intervention. There are three main categories of treatment of the body which may result in this type of assemblage; surgical intervention, autopsies and dissections but these are by no means mutually exclusive.

A total of 1828 bone fragments were recorded of which 12.9% (*n* = 236) exhibited evidence of medical intervention. In addition, 54 elements (3.0%) exhibited staining or drilling that was likely to be associated with peri-mortem modification by way of creating teaching specimens. The complete assemblage derived from a minimum of 27 individuals assuming that no remains of individuals were dispersed between contexts; on the same basis, the minimum number of individuals exhibiting evidence of peri-mortem medical modifications was 15. However, given the disposal or burial method it is assumed that all 27 individuals were exposed to some form of medical intervention and subsequently deprived of a traditional burial. The modified part if the assemblage represented both males (71.4%, n = 15) and females (28.6%, n = 6) based on the sexed fragment distribution and included both sub-adults (20%, n = 23) and adults (80%, n = 92) based on the aged fragment distribution.

Historical background

Research indicates that Worcester Royal Infirmary took in students for anatomical training at what was apparently an exorbitant fee of 20 guineas to the physicians and 30 guineas to the surgeon per annum at a time when fees in more distinguished establishments such as Edinburgh were only 5 guineas per annum (McMenemey 1959, 80). Such high fees must only have been possible if the facilities at the Infirmary were geared towards a high level of teaching, including practical experience. The students would have been taught in a

go to next page

to previous view

traditional manner following practices adapted from Paris and Edinburgh, gaining experience in patient care by attending the wards with in-house physicians and surgeons, but also gaining knowledge of practical anatomy and surgery by hands on experience of dissection (McMenemey 1959, 52). The infirmary may in such case have accommodated both a dissection room for practical work and a lecture theatre for teaching and demonstrations, similar to those depicted in Plates 18 and 19.

The post-mortem human modifications of the skeletal remains may therefore represent a number of practices such as dissection for the purpose of teaching, autopsies to establish the cause of death and/or amputations from surgical practices at the hospital. The purpose of the following analysis is to establish whether the remains may represent one or more of these practices within the Infirmary.

Plate 18: The interior of a dissecting room in Edinburgh, with half-covered cadavers on benches. Photograph 1889

go to next page

Plate 19: A lecture theatre at the Hunterian Anatomy School,Great Windmill Street, London. 1830

Methodology

Recording of peri-mortem modifications

Peri-mortem modifications were recorded by Western according to the methodology based upon Reichs (1998, 359; Table 10).

Knife mark	Saw mark	Axe mark
Narrow (≤ blade dimension)	Wide (≥ blade dimension)	Very wide
V-shape in cross-section	Square in cross-section	V-shape in cross-section
Smooth (or microscopic striations)	Visible striations	Smooth (or microscopic striations)
Striations perpendicular to the kerf floor	Striations parallel to kerf floor	Striations perpendicular to kerf floor
Minimal wastage	Moderate wastage	Significant wastage/fracture/ chattering

Table 10: Categorisation of diagnostic features of peri-mortem modification

In addition, a category of 'incision' was introduced to describe fine, hair-like knife marks to the bone that were ≤ 1mm in width.

to previous view

The assemblage was divided into two groups: the first composed of fragments with evidence of saw, cut, knife and/or chop marks and the second comprising of those elements with staining and fixings. The first group were thought to be most likely to represent the remains of individuals subject to post-mortem surgical procedures at the Worcester Infirmary. The second group were more likely to represent natural specimens used for teaching models, such as wired skeletons, which may have been prepared off-site and are discussed separately.

Analysis

For the purpose of analysis of the human skeletal remains the author has adapted the zooarchaeological approach based on disarticulated remains based on Klein and Cruz-Uribe (1984) and O'Connor (2000). Calculation of numbers in a zooarchaeological context are based on three categories.

- Number of Identified Specimens (NISP) = Fragment count only.
- Minimum Number of Elements (MNE) = Least number of elements present based on most frequent portion of bones present of each anatomical category.
- Minimum number of individuals (MNI) = The least number of individuals present based on elements, portion of element, side and when possible age and sex.

For the purpose of this analysis, only the NISP and the MNI were adapted as these were the figures allowing direct comparisons with similar sites.

Site	Abbreviation	Date	Reference
Worcester Royal Infirmary, Worcester	WRI	18–19th century	
Bristol Royal Infirmary, Bristol	BRI	19th century	Witkin pers comm (Phd thesis/wip)
*Newcastle Royal Infirmary, Newcastle	NRI	19th century	Boulter et al 1998 (unpublished report)
*Medical College Georgia, USA	MCG	19th century	Blakely and Harrington 1997 (published)
*Royal London Hospital, Whitechapel, London	RLH	18th–19th century	Powers 2010 pers comm (wip)
*Ashmolean Museum, Oxford	AMO	18th century	Hull 2003 (published)
Trinity College, Dublin	TCD	18th century	Murphy 2010 (Phd thesis)
University College London, London	UCL	19th century	Birch 2010 pers comm (wip)
*Craven Street Anatomy School	CSAS	18th century	Kausmally 2010 pers comm (Phd thesis/wip)

*Table 11: Archaeological investigation of medical establishments, showing abbreviations used in this report. (wip – work in progress; * – reports available to the author)*

go to next page

to previous view

Comparative sites

The study of modified skeletal remains from archaeologically excavated medical establishments is a relatively recent undertaking, resulting in limited comparatives, many of which are provisional (Table 10). To date there is no formalised method of recording such remains with adaptation of various methods of recording from traditional osteological methods to zooarchaeological and forensic approaches or a combination of the above. This has resulted in a high degree of variability of analysis and has limited the scope for direct comparison between sites. The reports available to the author have been marked with an asterisk in Table 11 and have been adapted where applicable. Any variation in recoding from that of Worcester Royal Infirmary has been noted in the captions or in the text.

Results

Prevalence rates of cuts

Based on the NISP count Worcester Royal Infirmary showed modifications of almost all skeletal elements in the body. Areas most frequently cut were the skull and the lower limb bones followed by the upper limb bones (Table 12).

Category	Total	Total %	Modified	% modified by element	% modified of all bones
Cranium	82	4.5	26	31.7	11.0
Mandible	6	0.3	2	33.3	0.8
Clavicle	25	1.4	6	24.0	2.5
Scapula	47	2.6	4	8.5	1.7
Humerus	77	4.2	13	16.9	5.5
Radius	54	3.0	8	14.9	3.4
Ulna	57	3.1	7	12.3	3.0
Unidentified long bone fragments	9	0.5	2	22.2	0.8
Hand	82	4.5	0	0.0	0.0
Vertebrae	221	12.1	44	19.9	18.6
Sternum	10	0.5	0	0.0	0.0
Ribs	582	31.8	17	2.9	7.2
Pelvis	80	4.4	6	7.5	2.5
Sacrum	23	1.3	2	8.7	0.8
Femur	114	6.2	41	36.0	17.4
Tibia	110	6.0	45	40.9	19.1
Fibula	65	3.6	11	16.9	4.7
Patella	6	0.3	0	0.0	0.0
Foot	178	9.7	2	1.1	0.8
Total	***1828***	***100***	***236***	***12.8***	***100***

Table 12: NISP distribution of Worcester Royal Infirmary showing total number of fragments present within each category and the NISP of modified elements

go to next page

to previous view

Comparing the NISP rates with those calculated at Medical College Georgia and Craven Street Anatomy School, Figure 12 shows the percentage of bone fragments cut within each element group, whilst Figure 13 shows the percentage of cut elements relative to the total number of cut elements in the whole assemblage.

From Figure 12, it was evident that a high proportion of the skull fragments were cut at Worcester Royal Infirmary as well as those of the lower limb bones, in particular the tibiae and femora. A similarly high percentage of lower limb bone cuts were seen at Craven Street Anatomy School; however, upper limb bone cuts were much lower in prevalence at Worcester Royal Infirmary than at Craven Street Anatomy School, where bisection of limbs occurred more equally amongst upper and lower elements.

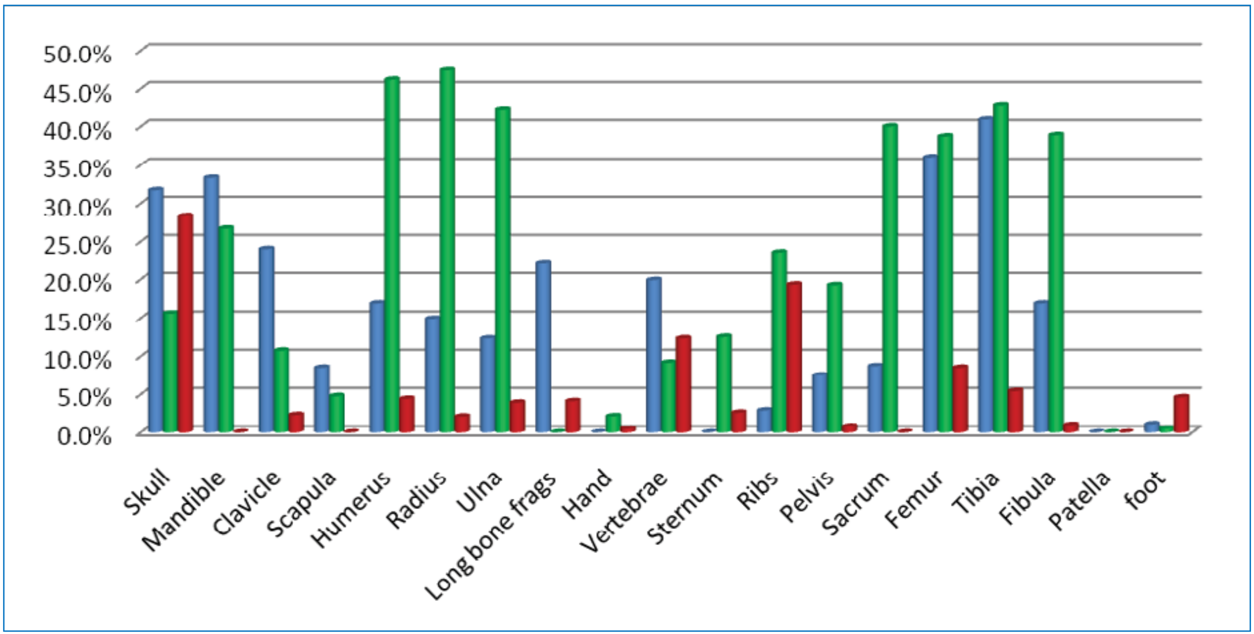

Figure 12: Percentage modified skeletal fragments within each skeletal category, based on number of identified specimens (NISP).
N = number of identified specimens (NISP)/n = NISP with modifications

Figure 13, illustrates the distribution of cuts within the entire skeleton. Here Medical College Georgia had a much higher proportion of cut skull elements than Worcester Royal Infirmary and Craven Street Anatomy School. It was further evident from this table that Worcester Royal Infirmary proportionally had a much higher cut rate in the lower limb bones that both Medical College Georgia and Craven Street Anatomy School, whilst the upper limb bones showed a more equal distribution. It is also apparent that the ribs were much less affected than those from Medical College Georgia and Craven Street Anatomy School although the vertebrae were more frequently cut.

Figure 14 has been added to this chapter to demonstrate the distribution of adults to sub-adults, as this to some extent affects the cut rate. Sub-adult bones are more fragile and modifications are often less apparent. It was in general noted at all sites that the sub-adults exhibited less modifications. It was also noticeable from this graph the demographic of the hospital sites varied significantly from that of the private Craven Street Anatomy School, which may have procured bodies for dissection in a different manner.

go to next page

to previous view

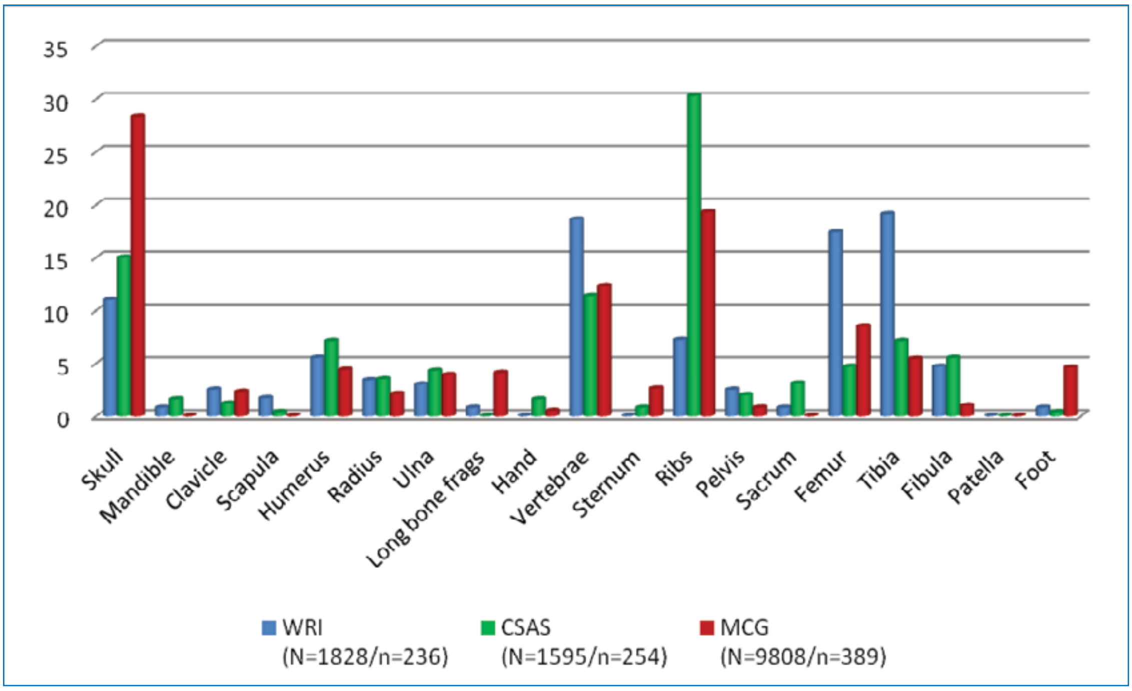

Figure 13: Percentage modified elements based on distribution of all skeletal elements. Based on number of identified specimens (NISP). N = number of identified specimens (NISP)/n = NISP with modifications

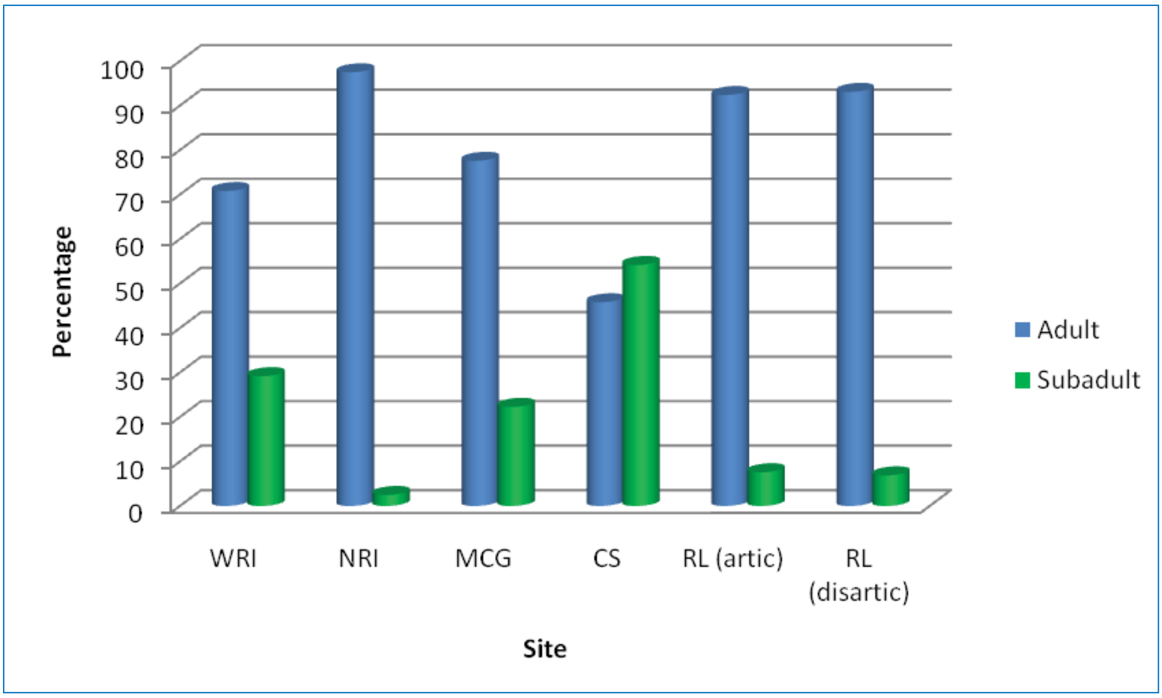

Figure 14: Percentage distribution of the minimum number of individuals (MNI) of adults and sub-adults. (Newcastle Royal Infirmary distribution based on the crania only. Medical College Georgia counts based on frequency of bones for which age was assigned)

go to next page

to previous view

Cranial modifications

A total of 83 skull elements were present in the assemblage of which, 31.3% (26) had been severed in one or more directions (Table 13; Fig 12). Most frequent were cuts in a transverse direction (61.8%) followed by longitudinal cuts (20.6%). Both adult and sub-adult cranial elements had been severed; considering the skull fragments to which an age category could be assigned, sub-adult fragments (28.6%, n = 2) were less frequently cut than adult ones (56.1%, n = 23; Plate 20).

Element	N =	Calvarium	Longitudinal	Transverse	Oblique	Trepanation
Frontal	6	4	1	4	2	0
Maxilla	0	0	0	0	0	0
Zygomatic	0	0	0	0	0	0
Parietal	4	4	0	4	0	0
Temporal	1	0	0	0	0	0
Occipital	11	11	2	11	1	0
Mandible	2	0	2	1	1	0
Sphenoid	1	0	1	0	0	0
Calvarium	1	1	1	1	1	1
Total	***26***	***20***	***7***	***21***	***5***	***1***

Table 13: Number of sawn elements of the skull and cut direction for each skeletal element

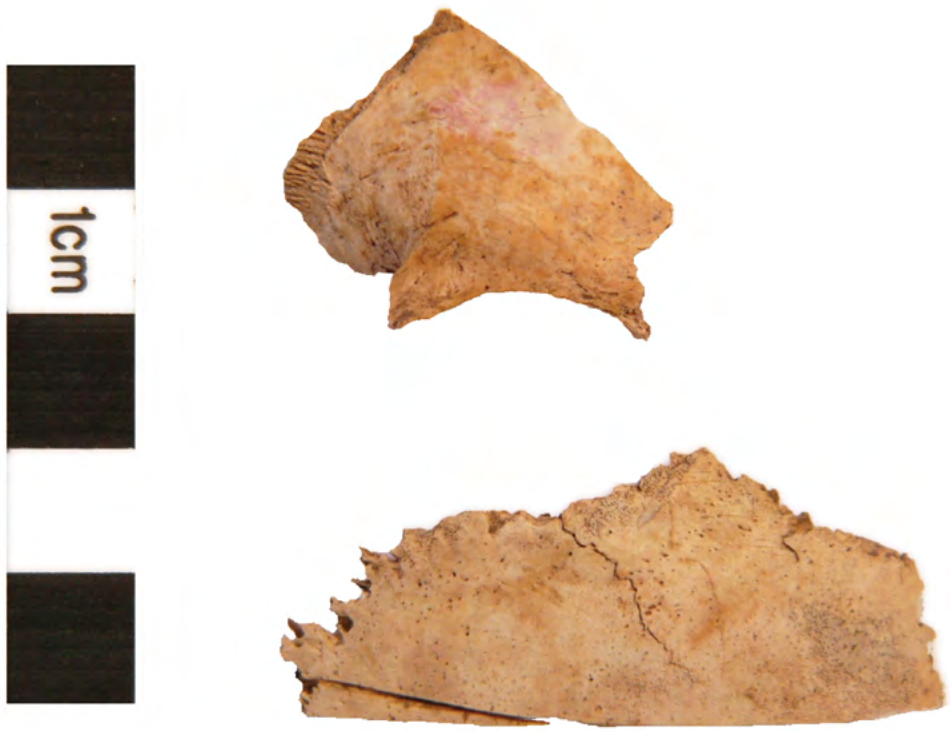

Plate 20: Infant bones with evidence of post-mortem cuts: Oblique cut to frontal bone above the eye orbit (top) and craniotomy cut (bottom)

go to next page

to previous view

The skull severed elements from Worcester Royal Infirmary followed a very traditional pattern of a head dissection, in a manner still carried out today. The following descriptions used as a comparative for Worcester Royal Infirmary were made by Blakely and Harrington (1997, 145) in an experimental dissection in connection with the findings at Medical College Georgia; 'In order to perform a calvarium cut the bone is scraped clean from external soft tissue leaving behind scrape marks commonly performed with a sharp blade.' A total of ten elements exhibited evidence of such practice, with multiple short incisions running parallel to the saw marks (Plate 21).

Holden (1851, 481) also describes a method for the removal of the soft tissue from the calvarium in his *Manual of Dissection of the Human Body*. 'Most convenient manner of removing the brain is to cut through the scalp across the top of the head, from one ear to the other, so that the anterior part of the scalp may be detached from the skull and pulled down over the face and the posterior part over the back of the head'.

Plate 21: Several parallel incisions from defleshing prior to craniotomy (ID 653)

Evidence of the practice of this method is seen on calvarium (ID 1287) where three overlapping incision marks were present; two incisions had been made on either side of the head at the location of the ear and ran upwards. A third incision was made across the top of the head between the two in order to join the two lateral cuts to complete the midline cut across the scalp. Several other incisive cut marks were also present across the calvarium resulting from the subsequent defleshing.

'Once the external soft tissue has been removed to expose the bone the calvarium cut is performed cutting the skull circumferentially approximately 2cm above the orbital margin and the external occipital protuberance. The cut can either be performed solely with a saw leaving a smooth saw surface or sawn partially to be completed by chiselling the remaining endocranial bone, leaving a raised margin'. The cuts performed at Worcester Royal Infirmary appear to have been performed as a single saw cut without the use of a chisel. Almost all skull elements observed had evidence of a calvarium cut present.

'Once the calvarium cut has been performed an occipital wedge may be cut for a deeper dissection. Cutting either side of the occipital bone in a longitudinal direction towards the

go to next page

foramen magnum'. At least one individual (ID 667 and 668) at Worcester Royal Infirmary showed evidence of such practice (Plate 22).

'The orbital region is then cut from the edge of the calvarium cut at an oblique angle towards the surpraorbital margin and into the frontal sinuses and posterior into the lesser wing of the sphenoid. Such cut allows examination of the orbital region'. Again at least two fragments had been cut in a similar oblique fashion toward the orbital roof (ID 648 and 671). One sphenoid was also cut, possibly as a result of this procedure.

'In some instances a sagittal cut is performed bisecting the skull, allowing a profile view of the internal organs as they are linked in the skull'. One occipital bone (ID 656) had a sagittal cut as well as two mandibles (ID 1121 and 1288), one in the area of the second lateral incisor and one at the midpoint of the mentum, suggesting that an attempt of skull bisection was carried out.'In some cases staining of the bone may be indicative of post mortem procedures such as preparations of anatomical specimens or experimental injections'. Staining was noted on four skull elements (three parietal and one occipital bone). The staining in this case was superficial green copper staining and is hence more indicative of post-burial staining from buried metal objects such as nails than being a result of actual medical intervention.

Plate 22: Removal of the occipital squame (back of the cranium) with cuts to the superior area and both sides (ID 667 and 668)

In addition to these modifications, an almost complete calvarium (ID 1287) resulting from a craniotomy was recovered from context (ID 10003) exhibiting evidence of a trepanation, followed by the removal of the adjacent area of left parietal bone via two cuts radiating from the circular hole inferiorly and posteriorly (Plate 23). Several parallel but slightly superiorly angulated marks on the cut surface indicate mechanical drilling. An inner lip of bone remains formed from endocranial bone. The hole, 18mm in diameter, exhibited no evidence of healing. The lack of bony healing indicates that the operation was performed at or around the time of death (peri-mortem). The additional presence of the similarly unhealed radiating cuts

to previous view

suggests that these modifications were made as part of anatomical dissection. One example of trepanation with was no sign of remodelling was also found at St Andrew's, Worcester, indicating that this patient did not live long after the operation was performed (Western 2006). Multiple examples of peri-mortem trepanning were present at Craven Street Anatomy School (Kausmally 2009, 101), Newcastle Royal Infirmary (Boulter *et al* 1998, 149) and the Royal London Hospital (Powers 2009, 32). At Newcastle Royal Infirmary the prevalence rate was, however, very low at only four examples. None of these cases were healed, suggesting they may have been performed by students practicing surgery rather than actual surgical intervention.

The saw cuts radiating from the trepanation create a large 'keyhole' shape through which the underlying soft tissue structures, such as the venous drainage system and pathological lesions, could have been observed. There are also incision lines running parallel to both these radiating cuts, *c*3–4 mm distant, indicating careful skin removal prior to sawing.

Plate 23: Trepanation with subsequent removal of parietal fragment (ID 1287)

lso recovered from context 10003 was one mandibular fragment (ID 1288) with evidence of modification for dissection (Plate 24). The cut marks observed closely follow instructions given for dissection of the pterygo-maxillary area of the head in the contemporary *Manual of dissection of the human body* written by Holden in 1851.

> Dissection to expose the internal maxillary artery. We must first remove with Hey's saw the zygomatic arch; this will expose the coronoid process of the jaw, the insertion of the temporal muscle and a considerable quantity of loose

go to next page

to previous view

fat and cellular which surround it. Next, saw through the coronoid process in a direction downwards and forwards, so as to include the whole insertion of the temporal muscle; and then turn it upwards with the muscle without injuring the subadjacent vessels and nerves. The next step is to saw through the neck of the jaw about 5/8ths of an inch below the condyle. Lastly, remove the recurring part of the neck close to the ramus of the jaw. By this mode of proceeding the region called the pterygo-maxillary will be fairly exposed (Holden 1851, 176).

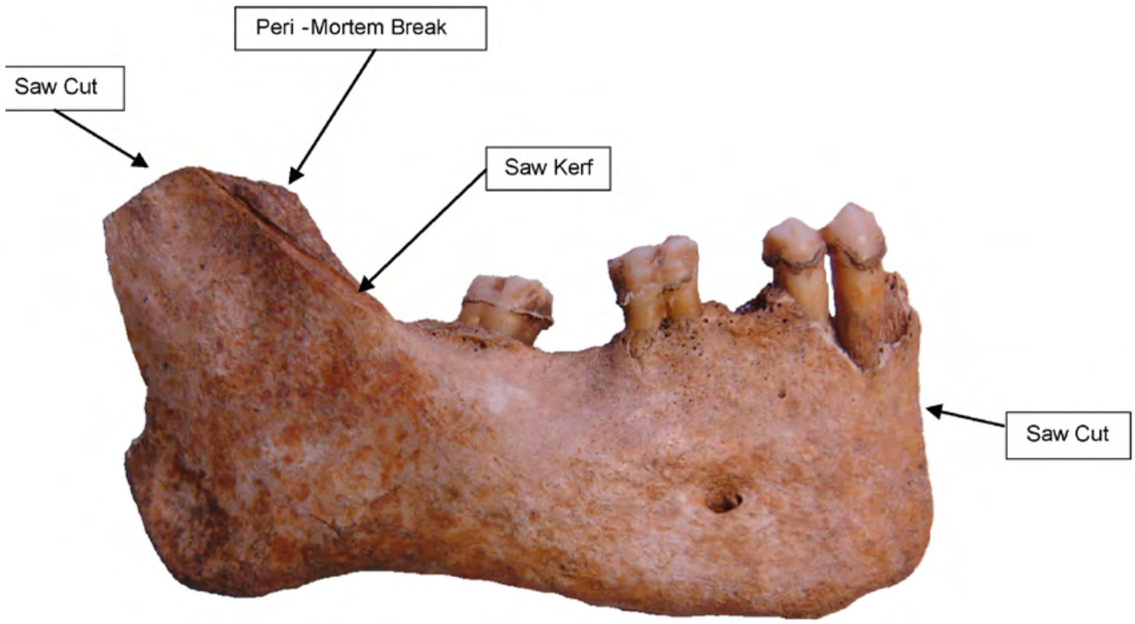

Plate 24: Sectioned mandible (ID 1288) exhibiting removal of the coronoid process. Also note the pipe-smoking groove between the canine and first premolar

It is clear that the superior section of the mandibular ramus has been removed through both sawing and snapping off the anterior portion. An oblique saw cut has also been made here, although incomplete and resulting in a deep false start kerf. This may be associated of the first cut Holden describes to remove the zygomatic arch lying anatomically superior to the coronoid process or could represent a failed attempt at the second cut to remove the coronoid process itself. A breakaway spur is located on the interior edge of the ramus indicating that care was taken not to damage the underlying soft tissue structures when removing the superior portion outwards. This also indicates that the temporo-mandibular joint was the last point at which the jaw was hinged by soft tissue to the cranium and that the jaw had previously been sectioned sagitally at the mentum.

Long bone cut

The assemblage consisted of 26.4% (482/1827) limb bone fragments, of which 18.3% (88/482) had some form of modification such as saw cuts, knife or chop marks. The most frequently modified limb bones were those of the lower body in particular femora (33.0%, n = 29) and tibiae (31.8%, n = 28; Table 14).

go to next page

to previous view

		Location of bi-section			Saw direction						Cut numbers	
Context/limb bone	**Total cuts**	**Prox**	**Mid**	**Dist**	**AP**	**PA**	**LM**	**ML**	**SI**	**N/A**	**One**	**Multiple**
5003												
Clavicle	0	0	0	0	0	0	0	0	0	0	0	0
Humerus	7	0	2	3	0	0	0	5	0	2	7	0
Radius	1	0	1	0	0	0	0	1	0	0	1	0
Ulna	3	1	0	1	1	0	1	0	0	1	3	0
Femur	24	5	8	10	13	2	1	3	0	4	23	1
Tibia	23	14	6	1	14	1	0	3	0	5	22	1
Fibula	8	1	3	1	1	1	0	0	0	6	7	1
Total for 5003	***66***	***21***	***20***	***16***	***29***	***4***	***2***	***12***	***0***	***18***	***63***	***3***
5001												
Clavicle	0	0	0	0	0	0	0	0	0	0	0	0
Humerus	1	0	0	1	1	0	0	0	0	0	1	0
Radius	2	0	0	2	0	0	1	1	0	0	2	0
Ulna	2	0	0	2	0	0	0	2	0	0	2	0
Femur	2	1	0	1	1	1	0	0	0	0	2	0
Tibia	5	3	0	2	1	0	0	1	0	3	5	0
Fibula	2	0	1	1	0	0	0	0	0	2	2	0
Total for 5001	***14***	***4***	***1***	***9***	***3***	***1***	***1***	***4***	***0***	***5***	***14***	***0***
5008												
Clavicle	0	0	0	0	0	0	0	0	0	0	0	0
Humerus	1	0	0	1	0	0	0	1	0	0	1	0
Radius	0	0	0	0	0	0	0	0	0	0	0	0
Ulna	0	0	0	0	0	0	0	0	0	0	0	0
Femur	2	1	0	1	2	0	0	0	0	0	2	0
Tibia	0	0	0	0	0	0	0	0	0	0	0	0
Fibula	0	0	0	0	0	0	0	0	0	0	0	0
Total for 5008	***3***	***1***	***0***	***1***	***2***	***0***	***0***	***1***	***0***	***0***	***3***	***0***
10003												
Clavicle	3	2	0	1	2	0	0	0	1	0	3	0
Humerus	1	0	0	1	1	0	0	0	0	0	1	0
Radius	0	0	0	0	0	0	0	0	0	0	0	0
Ulna	0	0	0	0	0	0	0	0	0	0	0	0
Femur	1	0	0	1	1	0	0	0	0	0	1	0
Tibia	0	0	0	0	0	0	0	0	0	0	0	0
Fibula	0	0	0	0	0	0	0	0	0	0	0	0
Total for 10003	***5***	***2***	***0***	***3***	***4***	***0***	***0***	***0***	***1***	***0***	***5***	***0***
Grand total	***88***	***28***	***21***	***29***	***38***	***5***	***3***	***17***	***1***	***23***	***85***	***3***

Table 14: Sites of election for bisection and direction of limb bones at Worcester Royal Infirmary for each context

go to next page

to previous view

In modern dissections long bones are rarely cut for the purpose of anatomical dissection, however, in the 18th and 19th centuries such practices may have been necessary due to shortage of bodies, in order to divide a single body amongst several students. In such case the bones would have been severed along the shaft in order to preserve joints for anatomical observation (Kausmally 2009). In some instances, superficial tissues would have been removed to expose associated deeper structures of the limb bones, producing cut marks and incisions on the cortical surface of the bone (Blakely and Harrington 1997, 141).

Such practices may be difficult to distinguish from therapeutic amputations; bisections could either be performed whilst the individual was still alive in order to remove a traumatised or infected limb or as part of practicing surgical procedures in the dissection room. Table 14 shows the location of severed limb bones and the saw direction in which they were performed. Very few bones had been cut more than once (3.4%). In the lower limb bones, the femur exhibited the most frequent rate of cuts to the distal (44.8%, n = 13) and proximal in the tibiae (60.7%, n = 17). Interestingly the tibiae and the fibulae did not display the same pattern of location with the fibulae only showing a 11.1% cut rate to proximal. This discrepancy may in part due to the fact that it is often not possible to identify the precise location fibula shaft fragments that have no epiphysis attached.

The most common cut direction of the bones were anterior to posterior (AP), which suggest, as suspected, that most of the subjects would have been lying in a supine position during severing. The upper limb bones showed slightly more variability with a higher degree cut in a medio-lateral (ML) position; this again was not surprising as the arm bones allow more flexibility of movement.

The kerf wall of sawn bones further demonstrated different cutting actions. At Worcester Royal Infirmary it was noted that bones were cut as a singular straight motion whilst other bones were cut with a rotating motion (Plates 25 and 26).

Plate 25: Distal left femur (ID 801) demonstrating a single direction cut

go to next page

to previous view

Plate 26: Left tibia (ID 896) demonstrating a rotating sawing action and a large breakaway notch

Extremities

Only 1.1% (n = 2) of elements from the extremities exhibited any surgical modifications; in fact, no such modifications were observed in the hand bones. Of the foot bones, one right sub-adult calcaneus (ID 793) from context 5003 exhibited a vertical bisection 34.7mm anterior to the epiphysis. In addition, one right talus (ID 821) from context 5003 had been sawn towards the posterior portion cut in a superior to inferior direction, suggesting that this was performed after the foot had been separated from the tibia.

The severed foot bones are most likely to have been cut during a practical anatomy lesson as there is no surgical procedure that would require severing of posterior portion of either the talus or the calcaneus.

Torso

Vertebrae

Evidence of modification of the spinal column was noted in all regions of the spine. A total of 19.9% of all the vertebral elements had been modified.

Of note was a set of what appeared to be associated cervical and upper thoracic vertebrae from context 10003. These vertebrae all had the posterior neural arch removed allowing access to the spinal cord for observation (Plate 27). This was a common practice in dissection and according to Holden (1851, 508–9): ‘the arachnoid membrane of the [spinal] cord…may truly be said to float in a fluid. This cerebro-spinal fluid cannot be demonstrated unless the spinal cord be examined soon after death and before removal of the brain. The proper mode of taking out the spinal cord is to saw through the arches of the vertebrae’.

go to next page

to previous view

Plate 27: Dissected cervical and upper thoracic vertebrae from context 1003 with bisected axis (second cervical vertebra)

It is clear that this practice was carried out at the Worcester Infirmary from the remains recovered. Interestingly, the removed *pars interarticulares* (posterior arch) were considerably under-represented (n = 4) compared to the number of the vertebrae recovered without the posterior arch (n = 33), which would have remained in situ in the cadaver after the spinal cord was dissected. This appears to indicate that there may have been separate events of discarding removed body parts according to when they were dissected out and that some body parts were retained longer than others. Most of the neural arches were cut from the posterior aspect, as would be expected, at the site of the zygapophyseal joints or the root of the transverse processes. One thoracic vertebral fragment (ID 285) exhibited a coronal saw cut posterior to the facet across the pedicle behind. This cut could only have been made from the superior aspect of the vertebra once it had been dissected out from the body, indicating a more involved process of anatomical preparation or investigation.

In addition, one second cervical vertebra (axis) was recovered which had been bisected transversely in order to remove the head (Plate 27). Defleshing marks were clearly visible on this element, indicating careful removal of soft tissues on the anterior aspect prior to sawing through the vertebra. It is noteworthy that the cut has been made higher up in the neck than would be seen with punitive decapitations, where the neck tends to be most commonly severed in the mid-cervical region (Aufderheide and Rodriguez-Martin 1998, 29).

go to next page

Five additional vertebrae had been bisected through the vertebral bodies, three in a transverse direction and two in a sagittal direction. One lumbar vertebra (ID 1165) has had the posterior arch removed before being transversely bisected through the body and lower arch, suggesting that the spinal cord was observed prior to splitting the vertebra in two. Such bisections may have been performed for several reasons, such as dividing the body into sections during anatomy classes or to expose soft tissue during anatomical demonstrations. Transverse cuts of the lower thoracic and lumbar vertebrae are commonly performed in modern dissection to separate the lower body from the upper and gain easy access to the pelvic region (Blakely and Harrington 1997, 142).

The number of modified vertebrae at Worcester Royal Infirmary was high, with vertebrae being one of the most frequently modified elements within the assemblage as well as in comparison to other sites (Figs 12 and 13). The rate of severed vertebrae at Newcastle Royal Infirmary was very low compared to that of Worcester Royal Infirmary; in fact no vertebrae from the burials had been cut. Evidence of anatomical preparations was, however, present in the vertebrae and sacrum with a total of 19 modifications (type unstated; Boulter *et al* 1998, 144). As at Worcester Royal Infirmary, there was clear evidence of vertebral dissection at Craven Street Anatomy School with the purpose of exposing the spinal cord and well as sectioning for body sharing (Kausmally 2009, 94).

Ribs, sterna and clavicles

Ribs may provide evidence of autopsies with the opening of the thorax via a Y-shaped incision requiring peripheral cuts through the ribs and sternum from the 2nd to the 6th ribs, further cuts may be seen on the central portion of the ribs in order to expose the internal organs (Blakely and Harrington 1997, 141). The primary cut, however, requires that the anatomist cuts the torso more laterally than the cartilage linking the sternum and the rib end. It is not uncommon to see the very tip of the sternal end severed in such a manner. At Worcester Royal Infirmary, it is clear from Hastings' reports that removal of the chest-plate was regularly undertaken in his post-mortem examinations. In one of his early papers on *The peculiarly soft state of the structure of the lungs*, Hastings states that in an examination of the lungs, '…the sternum, together with the cartilages of the ribs, were removed…' as part of his post-mortem procedure. Although Hastings does not detail how the removal of the chest-plate was carried out, this may suggest that cuts could have been made through the sternal cartilage itself rather than the ribs, in contrast to modern autopsy techniques. Indeed, Holden's contemporary *Manual of the dissection of the human body,* instructs the anatomist to:

> make a kind of a window, so to speak, into the chest by removing the greater part of the sternum and the cartilages of nearly all the true ribs…Cut through the cartilages of all the true ribs, excepting the first and the last, close to the bone of the rib, and then raise the sternum with its attached cartilages…; in doing this, great care must be taken not to wound the pleura, which is closely connected with the cartilages (Holden 1851, 192).

One of the initial observations Hastings presents of the lungs is whether they collapse on removal of the sternum. It may be that in order to make this observation, the removal of the chest-plate required a particularly meticulous approach and cutting of the ribs was avoided.

A total of 582 ribs were recorded with 2.9% 9 (n = 17) showing evidence of modification without staining (Table 15); the percentage of modification in part appears misleadingly low due to the fragility of rib elements, post-depositional breakage leading a much higher total sample number of fragments compared to other elements. Five rib fragments in total were bisected. Only two 'midshaft' ribs had been severed from context 5003; one rib fragment had been poorly severed in an unspecified location leaving a large breakaway spur on the visceral surface. Three further rib fragments exhibited evidence of bisection, but all these were identified as posterior fragments and the ribs were severed at or in the region of the rib heads. Thus, the cuts were made posteriorly to the back adjacent to the spine rather than anteriorly to the chest, clearly the result of dissection rather than a post-mortem examination of the chest. The majority of the ribs that exhibited evidence of modification had been defleshed (70.6%, n = 12).

Modification N = 17	**N =**	**%**
Sawn (severed)	5	29.4
Cutmarks (not severed)	5	29.4
Incisions (knife marks)	11	64.7

Table 15: Modifications noted on rib fragments (NISP = 582/17)

In order to remove the chest-plate, cuts must also be made through the sternum and/or clavicle to sever the sterno-clavicular and costo-clavicular ligaments and free the sternum in line with the cuts made through the sternal cartilages. In total, six clavicles were modified, only 1.4% of those present. Both adult and sub-adult clavicles had been modified. Three exhibited defleshing marks, two at the sternal end and one at the acromial end at the shoulder joint. Three clavicles were bisected, again, two at the sternal end and one at the acromial end. Bisection at the acromial end of the clavicle (part of the shoulder girdle) would have been carried out to remove the arm, though it is unclear as to whether this would have been part of an amputation procedure or for dissection. No cuts were observed to the sternum/manubrium at Worcester Royal Infirmary.

Overall, evidence for dissection of the chest was hence very scarce in the Worcester Royal Infirmary assemblage, whilst evidence of such cuts were clearly seen in the Craven Street Anatomy School assemblage with cuts of the ribs to the sterna and central portion of the body (Kausmally 2009, 98). At Newcastle Royal Infirmary the rate of cuts to ribs was also low with only one rib severed (Boulter *et al* 1998, 144).

Hip (pelvis and sacrum)

A total of six pelvis fragments and two sacra were recorded as having modifications (Plates 28 and 29). Two of the pelvis fragments had cut and chop marks but were not severed. One was the ischium of a sub-adult (ID 74) whilst the chopped bone was an illium of an adult (ID 85). The two severed pelvis were cut in a similar manner, showing a vertical bisection extending across the iliac blade just anterior of the sacroiliac joint. Both elements were cut from posterior to anterior.

In modern dissections, the pelvis is commonly separated from the torso at the level of 11^{th} thoracic and 4^{th} lumbar vertebra allowing a split of the pelvis in a sagittal direction (Blakely and Harrington 1997, 145). Such procedure would explain the cuts on the sacra.

to previous view

The cuts of the iliac bones are less obvious but may have been carried out after the splitting of the hips as this would allow easier access of cutting from posterior to anterior. Blakely and Harrington (1997, 142) noted that in some instances in modern dissections, the hip bones were sawn to allow exposure of the deeper tissues of the hip joints and it is not unlikely that this was what was attempted by the cuts performed on the iliac bones.

Plate 28: Bisected sacrum (ID 90)

Plate 29: Bisected ilium (ID 96)

Also present were two severed pubic bones (ID 1289 and 1290), likely to be associated. Ageing of the pubic symphyses suggested that they represented an individual aged between 35–45 years at death and the observable morphology appeared male. Bisection of the superior pubic ramus was evident approximately 40mm distant to the pubic symphysis as well as of the inferior ramus, again approximately 40mm distant to the inferior point of the symphysis (Plate 30). The bisection of the superior ramus is sagittal with parallel striae running superior–inferiorly across the surface. A large breakaway spur is located on the

go to next page

dorsal surface where a large portion of the cortical bone has also been snapped off. A 'false start' kerf is also located in alignment with this cut on the inferior ramus, where the saw blade has accidently cut it. The cut of the inferior ramus is located more posteriorly and is angulated anterio-inferiorly – posterio-superiorly. The striae run anterio-superiorly to posterio-inferiorly though they are almost vertical. One small false start kerf is located 2mm distant to and parallel with the cut on the ventral inferior area. One incision mark is located on the ventral surface close to the obturator formamen and is posterio-superior–antero-inferior c 5mm in length. This represents defleshing prior to bisection.

Plate 30: Pair of sawn pubic bones (ID 1289 and 1290), dorsal view

Instruction for such bisection can be found in Holden's *Manual of Dissection of the Human Body*:

> To make a side view of the pelvic viscera, one of the innominate bones – say the left – should be removed in the following manner. Detach the peritoneum and the levator ani from the left side of the pelvis; saw through the pubes about two inches from the symphysis; then by drawing the legs apart and cutting through the piriformis, sacro-ischiatic ligaments and ischiatic nerves, the innominate bone comes away easily enough. This done the rectum, or at all events its lower part, should be distended with horse hair and the bladder blown up through the ureter. Lastly, a staff should be passed through the urethra into the bladder (Holden, 1851, 362).

Holden also emphasises the importance of anatomical study of the structures surrounding the urethra in its passage through the sub-pubic arch and states that 'this part of the urethra demands special attention; for here the incision is made in lithotomy [removal of bladder stones], here is the most frequent seat of stricture etc.' (Holden 1851, 358).

to previous view

Shoulder (scapula)

One scapulae exhibited evidence of bisection constituting only 2.1% of all scapula elements (N = 47). The scapula (ID 446), recovered from context 5003, was cut through the acromion.

The arms are not commonly removed from the shoulder during dissection and it is not unlikely that the cutting of the acromion was a result of a shoulder amputation. Such amputations may have taken place in case of injuries to the joint or pathology such as tumour growth (Liston 1838, 248).

Three further scapula fragments (6.4%) from context 10003 exhibited incision marks. Two of the fragments were identified as adult, the remainder being unobservable for age at death; the first was identified as male and the second as possible male from metric analysis of the glenoid cavity. The frequent and overlapping incision marks were observed clearly represent a concerted effort to deflesh these elements, with particular aims of removing of subscapularis, deltoid (inferior) and trapezius (superior) muscle attachments.

Element	Cut n =	Disease n =	% cut bone with disease
Cranium	26	3	11.5
Mandible	2	0	0.0
Clavicle	6	0	0.0
Scapula	4	0	0.0
Humerus	13	3	23.1
Radius	8	2	25.0
Ulna	7	0	0.0
Hand	0	0	0.0
Vertebrae	44	0	0.0
Sternum	0	0	0.0
Ribs	17	3	17.6
Pelvis	6	0	0.0
Sacrum	2	0	0.0
Femur	41	10	24.4
Tibia	45	24	53.3
Fibula	11	4	36.4
Patella	0	0	0.0
Foot	2	0	0.0
Long bone fragments	2	0	0.0
Total	***236***	***49***	**20.8**

Table 16: Rate of severed bones exhibiting evidence of pathology

Cut bones with disease

Over one fifth of bisected skeletal elements (20.8%) were affected by macroscopically observable pathological changes (Table 16). The most frequently affected elements were the lower limb bones, with the majority of these exhibiting infectious diseases (tibia 79.2%, femur 40.0% and fibula 75%; Table 17).

go to next page

to previous view

Pathology	Skull	Upper limb	Torso	Lower limb	Total
Congenital	0	0	0	1	1
Infectious	2	3	3	23	31
Trauma	0	1	0	6	7
Joint	0	0	0	1	1
Metabolic	0	0	0	0	0
Neoplastic	0	0	0	0	0
Other	1	1	0	8	10
Total	***3***	***5***	***3***	***39***	***50***

Table 17: Disease categories recorded in cut elements

The high rate of infectious diseases in the severed lower limb is indicative of therapeutic amputation procedures. These may be the discarded portion of the bone once the amputation was performed. It is also possible, however, that the procedure may have been carried out as part of surgical training once the patient was deceased and brought to the dissection room.

At Newcastle Royal Infirmary (Boulter *et al* 1998, 136) it was noted that a large number of amputated bones displayed evidence of pathological lesions and similar patterns in pathology aetiology were recorded as has been found at Worcester Royal Infirmary. Witkin (1997, 59) observed that over 80% of lesions in bisected tibiae, for example, were associated with non-specific infection.

At Medical College Georgia the rate of infectious disease of the limb bones were not specified but the overall rate of infections was relatively low at 4.9% mainly affecting adolescent males. The rate was however not compared rate of severed bones.

At Craven Street Anatomy School the rate of cut elements with pathologies was low at 9.4%. Infectious diseases were mainly seen in the lower limb bones as seen in Worcester Royal Infirmary, but at a much lower rate (tibia 11.1%, fibula 28.6% and femur 0%). This was, however, not surprising as Craven Street Anatomy School did not carry out surgical procedures on living individuals, and did most likely not gain any of their anatomical subjects directly from the hospital such as would have been the case with Worcester Royal Infirmary.

The relatively high rate of cut lower limb bones with infectious disease from Worcester Royal Infirmary, may well be an indication that the bones were remnants of therapeutic amputation and not simply division of bodies during practical anatomy lessons, but these may not be mutually exclusive.

Discussion of the physical evidence

Surgical intervention

Amputation

The amputation techniques applied in the 18th and 19th centuries had to be rapid as people undergoing operations had to do so without pain relief up until the discovery of general anaesthesia in 1846 (Kirkup 2007, 68). There was no shortage of surgical manuals explaining the best procedures of amputation of various limbs (Plate 31). During the two centuries

go to next page

to previous view

the most favoured methods of amputation appear to be the ‘circular operative technique’ as devised by Cheselden in the 18th century and the ‘flap and transfixion technique’. The former simply cut the skin circumferentially about 4–5 inches below the intended cut area of the bone. The skin and muscle was then pulled back. Once the amputation was performed the skin would be folded over the stump. This method did, however, prove to have complications as the bone stump would often be left exposed and vulnerable after healing. The latter method was devised to overcome this complication as the two flaps cut on either side below the point of amputation would contain both skin and muscle tissue to cover the stump when severed. The problem with this method was that this was performed at a lesser speed and due to the lack of anaesthetics this could prove fatal to the more fragile patients (Liston 1838).

Plate 31: Amputations of arm and leg with diagrams to illustrate how to perform the operations. Engraving by F Sesoni, 1749. Wellcome Library Image ref: ICV No 16851

In Liston’s manual of practical surgery (1838, 251) he noted that amputation of the legs should be performed at one of two points, either midway between the knee and the ankle or close to their upper ends. A similar procedure appeared to have been adapted by Worcester Royal Infirmary, though it was noticeable that eight femora had been cut on the mid shaft. There was however no shortage of manuals on the subject of amputations from the 19th century and the topic was vividly debated in medical journals such as the Lancet (Symes 1855a and b) showing clear evidence of disagreement on best approach.

Experimentation of new amputation techniques undoubtedly took place at Worcester Infirmary. Henry Carden, surgeon from 1838 to 1872, developed a new transcondylar single-flap amputation technique of the femur, involving bisection of the lower leg through the cancellous bone of the knee joint itself at the distal epiphysis of the femur. This avoided the secondary complications of shock, exfoliation and sepsis often occurring with amputations through the diaphysis itself (Carden 1864, 416–21). Of equal benefit was the functionality of the healed stump; by using a single flap of skin and fat taken from the proximal area of the anterior tibia, suturing was undertaken on the posterior aspect of the thigh rather than across the end of the sawn bone as with the two flap transfixion method in use at Worcester in the early 19th century (Carden 1864, 416). The healed stump then had a much improved capacity

go to next page

for weight bearing. The new technique involved cutting a semi-circular flap of skin and fat reaching from the lateral aspects of femoral condyles to a point inferior to the patella (around the tibial tuberosity). Subsequently all skin, fat and muscle on the posterior side of the femur between the two points forming the base of the anterior flap were severed. The flap was then reflected before severing the muscle lying beneath to the bone on the anterior side. After this, the muscles were cleared slightly superiorly and the bone sawn through below at the level of the condyles. The knee was flexed to a right angle prior dividing the muscles anteriorly, to draw down the patella. Carden notes that the popliteal artery and vein must be separated for a length of about an inch upwards in order to allow the vein to close over. Once the flap had been sutured or pinned on the posterior aspect the skin was drawn tight by the retraction of the flexor muscles. Carden (1864, 416–7) reported that having adopted this amputation technique in 1846, he and his colleagues at the Worcester Royal Infirmary had experienced notable success in employing this method, with survival rates of 78% of their patients, the deaths of some of the patients being due to the cancers they were being treated for rather than a failure of the amputation itself. After receiving recommendation from Syme, one of the most esteemed surgeons of the day, 'The Carden Amputation', gained considerable attention in contemporary medical journals both in England and America and indeed 'most of the noted surgeons of Great Britain followed their example' (Wood 1872, 1). Remarkably, one example of the transcondylar amputation technique survives in the assemblage (Plate 32).

Based on evidence from Worcester Royal Infirmary it is reasonable to conclude that at least some, if not the majority, of the bones were the severed as the result of therapeutic amputations, given the high prevalence rate of infectious disease observed on the bisected elements.

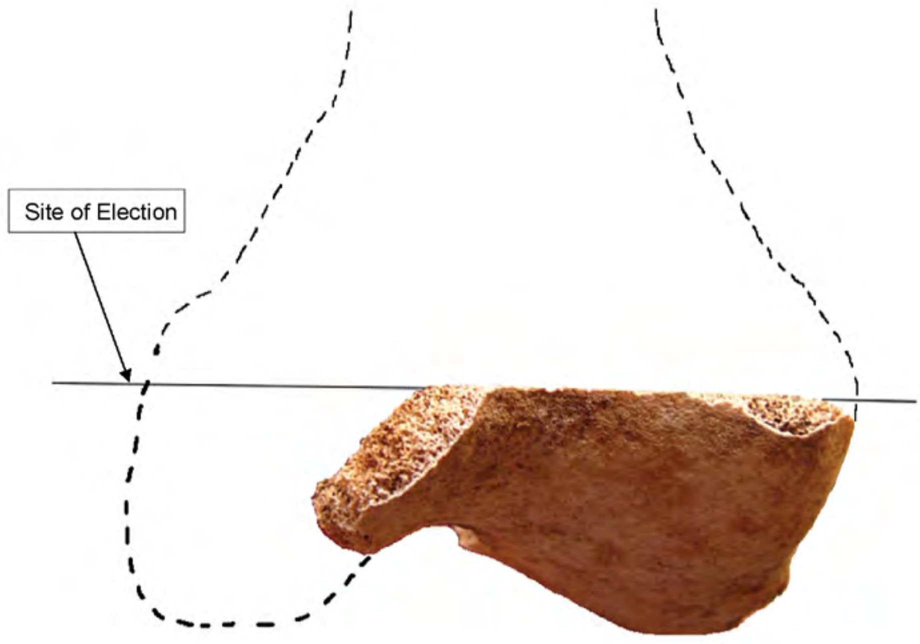

Plate 32: Example of the transcondylar single-flap amputation technique of the femur developed by Henry Carden (ID 791)

In one case, a femur (ID 785) displayed evidence of severe lytic lesion of the greater trochanter (Plate 33). The bone had been partially severed along the femoral neck. It is not unlikely that this specimen represent a failed amputation. It would have been necessary for the surgeon to attempt removal of the limb at this point to remove the infection, but amputations so close to the joint were notoriously dangerous and difficult and often only carried out as a last resort (Symes 1855a and b).

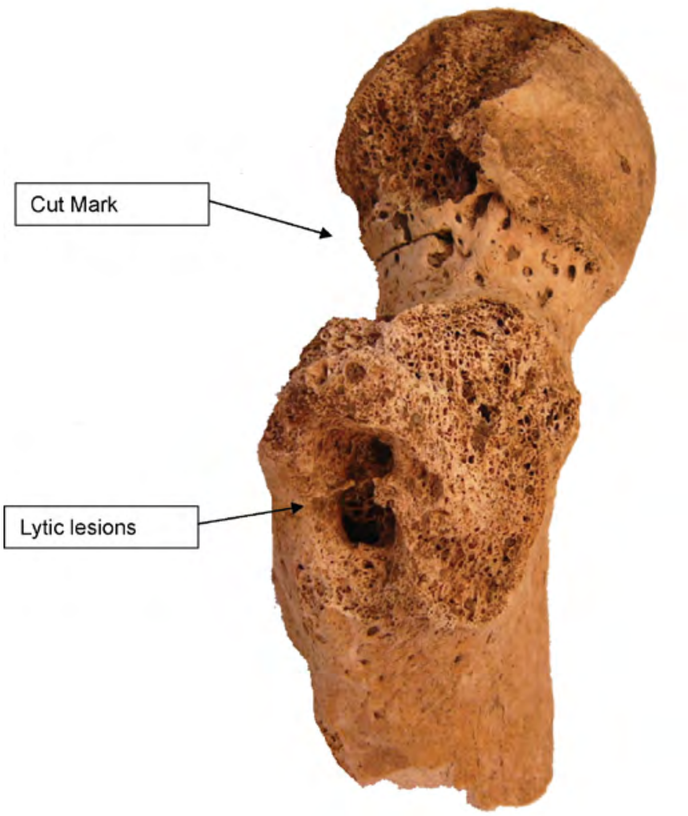

Plate 33: Femoral head (ID 785) with large lytic lesion of the greater trochanter and cut mark to the femoral neck

In 1791, Benjamin Bell, in his *System of surgery* listed the cases requiring amputation as follows:

> Bad compound fracture.
>
> Extensive lacerated and contused wounds.
>
> A portion of a limb being carried off by a cannon-ball, or in any other manner, if the bones be unequally broken and not properly covered.
>
> Extensive mortification (including gangrene).
>
> White swellings of the joints.
>
> Large exostoses, whether they be confined to joints, or spread over the whole bone or bones of a limb.
>
> Extensive caries, accompanied with bad ulcers of the contiguous soft parts.

Cancer, and other ulcers of an inveterate nature.

Various kinds of tumours.

Particular distortions of a limb.

Bell is keen to emphasise that in the advent of a fractured limb, it would have to be severely traumatised to justify surgical removal; whilst this would be more common in the scenario of war and at sea, Bell (1791, 305–6) suggests that amputation of a fractured limb would be appropriate rarely in private practice ‘where the patient can be from the first placed in an easy comfortable situation, from which he need not be removed till his cure be completed; where he can be kept perfectly quietly, and have all the advantages of good air, a proper regimen, and the assistance of able practitioners’. It is pertinent to note, however, that by 1859, 71.6% of amputations reported by a group of provincial infirmaries in England were the result of accidents, a number resulting from gunshot wounds to the foot, but many occurring in the workplace (Provincial Practice of Medicine and Surgery 1860, 446), testifying to the increasingly hazardous nature of industry following the introduction of mechanisation. Carden (1864, 416–7) reports that in his development of the transcondylar single flap technique amputation at the knee, he undertook 28 such operations at Worcester Royal Infirmary between 1859 and 1863. Of these, 46.4% were due to accidental trauma and 53.6% were to relieve the patient of diseased limbs.

Distinguishing surgical amputation from post-mortem intervention may prove difficult, and there is no conclusive method of deciding whether these were performed on living or dead individuals where no evidence of healing is recorded. Witkin (1997, 83) suggests that post-mortem bisections may be evident where the site of election is unusual in relation to anatomical structures, where sawn surfaces appear burnished and striations are weak indicating that a blunt saw was used, where breakaway notches or spurs are unusually large or where the sawn striations indicate a rotated cutting action. Evidence of post-mortem bisection according to Witkin’s criteria was observed on a total of thirteen elements in the Worcester Royal Infirmary assemblage. As seen in Plate 26, left tibia (ID 896) demonstrated a rotating sawing action, also seen in tibia (ID 43) and fibula (ID 1020), as well as a large breakaway notch. Four additional bisected elements, one ulna (ID 510), one rib (ID 275), one tibia (ID 897) and one humerus (ID 1139) exhibited large breakaway spurs or notches on their sawn surfaces; only one direction in sawing was evident. As well as exhibiting a large breakaway notch, a deep false start saw kerf was found running obliquely across the posterior aspect of the olecranon process of ulna (ID 510) that clearly served no surgical purpose. The sawn edges of three tibiae (ID 35, 45 and 59), one humerus (ID 1100) and two femora (ID 67 and 774) all exhibited burnished surfaces without evidence of large breakaway notches.

As can be seen from Table 18, there is little difference in choice of the site of election for the elements that may have been bisected post-mortem. If these cuts were made post-mortem, this may indicate that at least some of these bisections were carried out according to the methodology employed for therapeutic amputations. Similarly, the portion present relative to the bisection cut is ambiguous, though it would expected that a successful therapeutic amputation would only result in distal portions being present. It is interesting to note that only three elements (ID 45, 43 and 774) exhibit gross pathological changes, in contrast to the high rate of bisected limb bones with pathological changes from the assemblage as a whole, although overall the sample is small and it is difficult to draw any firm conclusions.

to previous view

ID no	Element	Side	Age	Site of election	Portion	Pathology	Observations
897	Tibia	Left	-	Proximal/tid third	Distal	None	Large breakaway spur
1139	Humerus	Left	Adult	Distal third	Distal	None	Large breakaway spur
510	Ulna	Right	Adult	Proximal third	Proximal	None	Large breakaway spur, cuts
35	Tibia	Right	Adult	Distal third	Proximal	Enthesophyte	Burnished
45	Tibia	Right	Adult	Proximal third	Distal	Undiagnosed	Burnished, cuts
59	Tibia	-	-	Proximal third	Proximal	None	Burnished
67	Femur	Left	-	Distal third	Distal	None	Burnished
774	Femur	Right	-	Distal third	Proximal	Rarefied	Smooth surface, weak striations
1100	Humerus	Right	-	Distal third	Distal	None	Burnished, weak striations
896	Tibia	Left	-	Proximal third	Distal	None	Circular cut
43	Tibia	Left	-	Prox/mid third	Distal	Diffuse periostitis	Circular cut
1020	Fibula	-	-	Distal?	Mid third?	None	Step in outline of cut, probably circular

Table 18: Observations of possible post-mortem long bone bisections

Autopsies/dissection

Distinguishing between autopsies and actual anatomical dissection may prove difficult as many of the cutting procedures are mirrored in the two procedures. Yet the two procedures are performed for very different reasons; autopsies were performed solely for the purpose of establishing the cause of death, whilst dissections are carried out with the purpose of understanding the function and anatomy of the body.

Evidence of autopsies has been recovered from a number of post-medieval cemeteries in recent years mainly in the form of craniotomies and occasionally evidence of opening of the thorax. Several such examples were recorded at St Bride's lower cemetery, Farringdon where no less than 23 craniotomies had been performed (N = 544, CPR = 4.2% with at least three individuals also having severed ribs (online resources, CHB, Museum of London). Chelsea Old Church, London (Cowie *et al* 2008, 50) had one individual with a craniotomy and likewise at St Benet Sherehog, (online resources, CHB, Museum of London). Seven examples of craniotomy were identified at St Martin's churchyard in Birmingham (N = 505, CPR = 1.3%; Brickley *et al* 2006, 146). One example of a craniotomy was also found at the

go to next page

local parish churchyard at St Andrew's, Worcester (N = 24, CPR = 4.2%; Western 2006) and the cutmarks observed to the clavicle and sternum of an individual from Tallow Hill Cemetery, Worcester (N = 10, CPR = 10%; Ogden 2003) are considered here to be likely to represent post-mortem opening of the thorax. Additionally, evidence for post-mortem modifications were recorded amongst the human remains from the Zion Chapel burial ground in Hereford (Brickley and Ives, 2002). The overall CPR of autopsies ranges from 0.72–4.2% with higher rates seeming to be present in poorer parish churchyards (Roberts and Cox 2003, 514).

It is reasonable to assume that the majority of the craniotomies were the performed as a consequence of an autopsy and hence reflect such a procedure. Comparing these with the cranial cuts at Worcester Royal Infirmary, it becomes apparent that the cranial cuts were more extensive at Worcester Royal Infirmary with the presence of the occipital wedge and cuts into the orbital regions. None of these cuts were performed in the craniotomies uncovered at the lay cemeteries in London and only one example was observed at St Martin's, Birmingham. It is hence reasonable to assume that the cranial modifications as Worcester Royal Infirmary were a result of cranial dissections rather than an autopsy or at least, further anatomical investigation was carried out subsequent to the initial post-mortem.

Anatomical preparation for demonstration

Fifty-four elements showed evidence of being preparations for anatomical demonstration, such as staining (discussed earlier), mounting or articulation of a skeleton. One femoral head had been penetrated by a metal pin (ID 786) placed to affix the head to the acetabulum of the pelvis. An additional cut had been made in the superior portion of the head for a copper fixing, indicated by the green staining (Plate 34). Radiographs taken of the element indicate that a plate of copper has been slotted into the head, perpendicular to the subsequently inserted nail, thus, strengthening the fastening (Plates 35 and 36). Additionally, the proximal most part of the nail is still attached to a punctured fastening, which may have formed part of a bracket, a fixing technique which is still used today to allow easy manipulation of the leg for demonstration purposes.

Plate 34: Femoral head (ID 786) with metal pin for articulation of a skeleton for the purpose of demonstration

to previous view

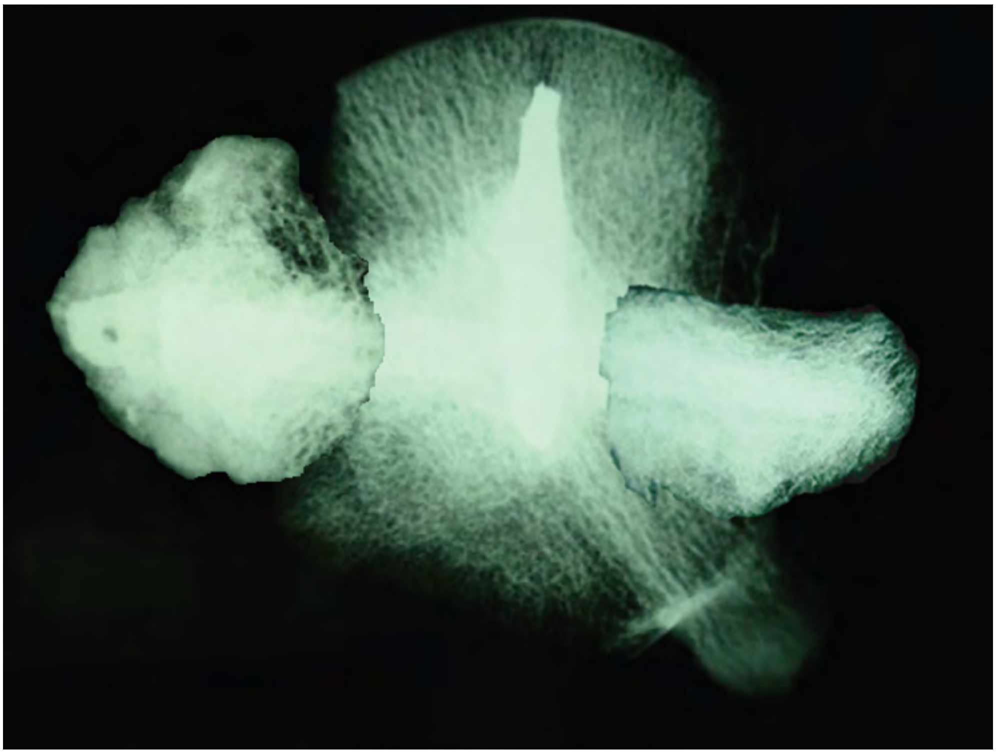

Plate 35: Composite of radiographs of femoral head (ID 786) illustrating vertical plate and horizontal pin with fragment of bracket attached

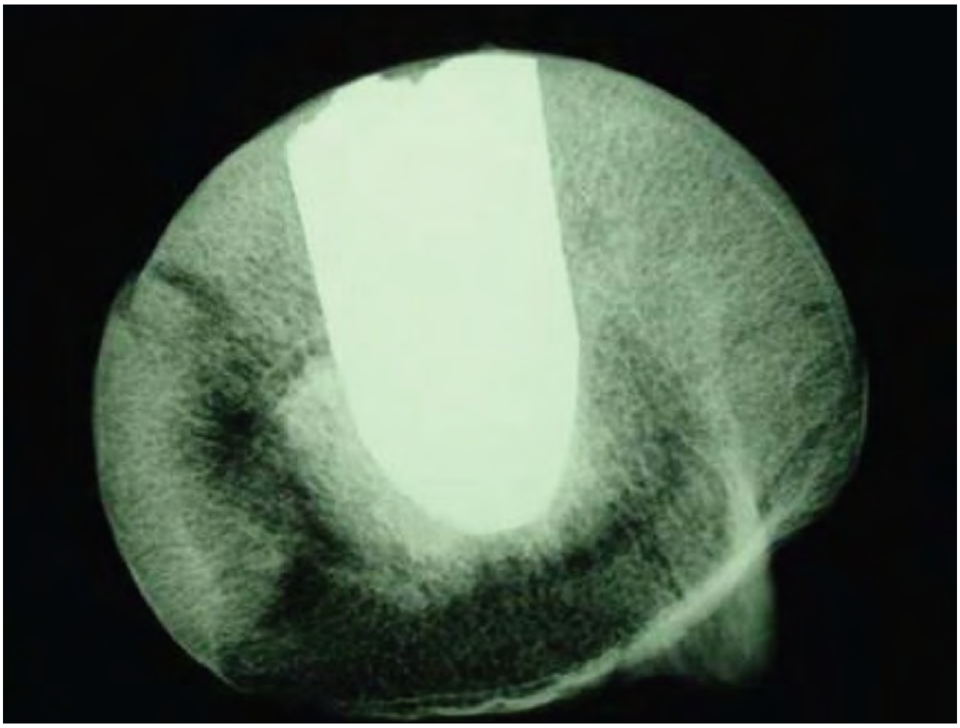

Plate 36: Radiograph of femoral head (ID 786; anterior view)

go to next page

to previous view

Plate 37: Ribs with penetrating metal wires and holes drilled for articulation of a skeleton for the purpose of demonstration

A number of ribs had been drilled and wired or pinned for articulating the torso of a skeleton (Plate 37). These are most likely to represent preparation of a skeleton for teaching demonstration, discarded following damage or at the end of use.

Method of disposal

Looking closely at the Worcester Royal Infirmary assemblage, there were observable differences in composition and manner of deposits. It was clear, for example, that context 5003 was a fill within a large pit and represented a major depositional event of many skeletal elements whilst context 10003 was a small, discrete burial of a more limited number of remains. Examination of the comparative array of elements contained within the contexts illustrates that there may have been different origins and motives for the deposits. For example, from Figure 15 below it can be seen that whilst all elements are represented in contexts 5003 and 10003, there is a comparatively high number of torso and foot elements represented in context 10003. Since other body areas in context 10003 are relatively evenly represented, this suggests a relative absence of torso and foot elements in context 5003. In addition, disparities can be seen in the distribution of bisected elements between contexts. As well as the absence of torso elements already noted in 5003, Figure 16 highlights the significant number of bisected limb-bone also contained therein. In fact, context 5003 contains 88.9% of all bisected femora and 100% of the bisected tibiae, the most commonly modified elements in the assemblage. In contrast, 86.1% of bisected vertebrae and 60% of

go to next page

to previous view

bisected ribs were found in context 10003. The composition of the skeletal assemblages, in tandem with the observations of the archaeological features they were contained in, suggests two different modes of disposal relating to the nature of the material. Whilst both deposits overlap to a certain extent in their composition and evidence of dissection is present in both, the presence of high numbers of bisected limb bones in a fill of the large pit 5004 (fill 5003) suggests that it includes an industrial deposit of surgical waste from the hospital. In contrast, the disposal in the shallow pit 10004 (fill 10003) of a smaller number of elements that relatively evenly represent all body areas and include a high frequency of bisected torso elements, suggests that this feature may well represent a discrete deposit of associated anatomised elements. MNI analysis confirms that only three individuals were represented in context 10003 (Table 1), with only 2.9% of the elements identified as one sub-adult, thus suggesting that the majority of the skeletal material represented two adults.

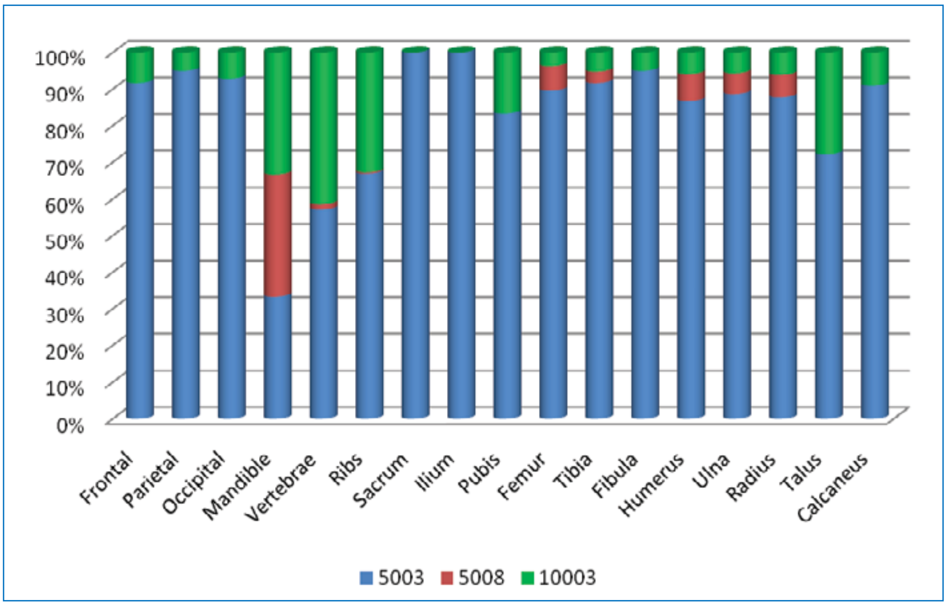

Figure 15: Percentage of elements present according to context (NISP)

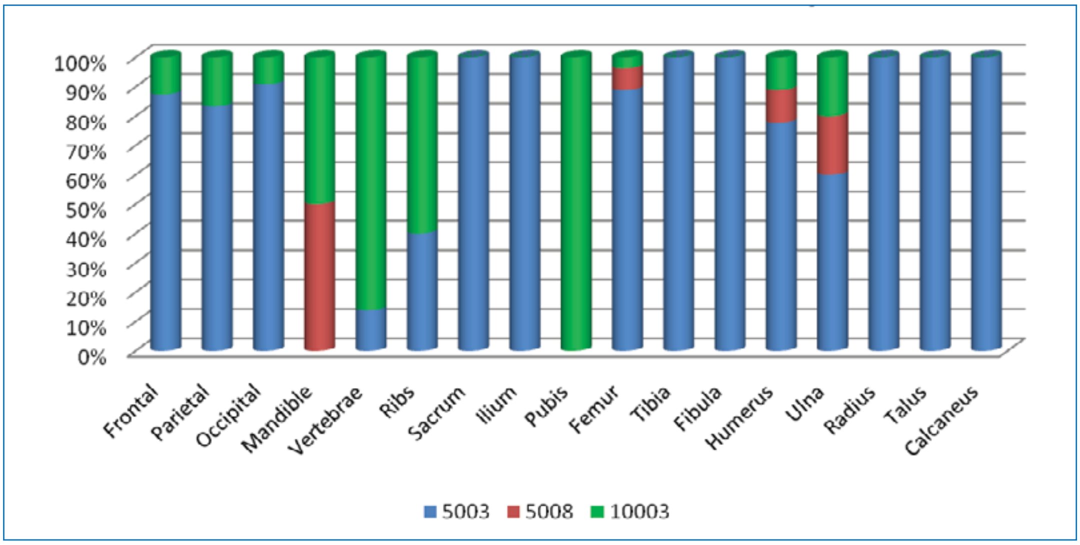

Figure 16: Percentage of bisected and elements present according to context (NISP)

go to next page

Unfortunately, no comparisons could be made to context 5008 since the sample size was very small (N = 30) although the data has been included here for observation. Additionally, although the sample from context 5001 was a comparable size it represented a disturbed context.

Corroborating the discussion above, the large industrial type deposit (context 5003) also contained all the specimens exhibiting direct evidence of being used as anatomical teaching models (ie incision marks, cut marks, drilling, wiring), although some elements exhibiting staining only, a more ambiguous indicator of modification, were contained in all contexts except 5008.

Conclusions for the physical evidence

The Worcester Royal Infirmary modified assemblage was a deposit of remains following medical intervention. Evidence of dissection, amputation and anatomical preparations were evident throughout. Comparing Worcester Royal Infirmary with similar sites such as Newcastle Royal Infirmary, Medical College Georgia and Royal London Hospital a similarity was apparent not only in the demographic profiles of the sites, but also in the prevalence rate of the cut locations. The cut rate proved particularly high in the skull, vertebrae and lower limb bones but with low cut rates in the ribs. Comparing these results with Craven Street Anatomy School, which was a private establishment not linked to any hospital, the difference was noticeable. The demographic profile at Craven Street Anatomy School showed a much higher rate of sub-adults, and the cut locations were more equally distributed across the skeleton. This difference may prove an important point, as the higher rate of lower limb bones at the hospitals, may signify a higher rate of therapeutic amputations rather than simply division of body parts during dissection. The rate of pathologies, and in particular lower limb infections, being higher at the hospital site further supports this notion. The fact that limb bones are rarely severed during a dissection suggests again that amputations were performed either on living patients or by the students on cadavers as part of their medical training.

In addition to the evidence for therapeutic amputations, cuts and knife marks were present that were clearly not related to surgical procedures. Some of these cuts, such as those to the posterior rib cage, pelvis and those found in limb-bones sharing the diagnostic criteria for identifying post-mortem bisection of suggested by Witkin (1997) clearly represent dissection practice. Other cuts, however, could represent either dissection or autopsy (‘post-mortem’) procedures, due to the fact that until the standard procedures of the autopsy were established by Virchow in 1874 and widely implemented in Britain during the 1880’s (Virchow 1880), studies of morbid anatomy and post-mortem examinations were mutually inclusive practices. When compared to craniotomies at other cemeteries, it was evident that some of the cranial cuts at Worcester Royal Infirmary were elaborate and followed the description of an experimental dissection performed in connection with Medical College Georgia as well as the methods suggested by the contemporary anatomist, Holden. Nonetheless, it is apparent from the literature that in some cases, more extensive cuts were made as part of the post-mortem procedure by Hastings and likely by his colleagues, in an attempt to further understand unidentified observed lesions and to establish the cause of death (Hastings 1827; Hastings 1855). Therefore, it can be difficult to categorically differentiate between ‘autopsy’ and ‘dissection’ procedures, particularly where certain elements or body areas are more frequently represented in the assemblage than others.

to previous view

The assemblage, despite consisting only of disarticulated skeletal elements, has brought to light the undertakings of the medical establishment at Worcester Royal Infirmary. Worcester prison was also very close to the Infirmary and was a source of bodies (from hangings) for practicing anatomy. Unfortunately, there was no direct indication whether the assemblage represent individuals procured prior to or after the Anatomy Act of 1832, though it is clear from the demographic profile that the bodies could not solely have been obtained from the gallows with the relatively high proportion of sub-adults present. Without knowing the timeframe of the excavated assemblages there is no way of speculating on the rate at which bodies were procured and discarded. It can only be assumed that the hospital must have had access to bodies from the wards, as well as those acquired from the gallows. It is hard to imagine that unclaimed bodies of families who could not afford burials would not have been withheld by the hospital for the purpose of dissection. Certainly with the emergence of the 1832 Anatomy Act it became legal to obtain bodies of unclaimed individuals.

go to next page

Faunal remains

By Tania Kausmally

Introduction

Faunal remains are not uncommonly uncovered from archaeological contexts of medical origin. Comparative anatomy was practiced in the 18th and 19th centuries and vivisections of animals were not uncommon where demonstrations required a living subject.

Prior to the Anatomy Act of 1832 publicly presented papers rarely discussed the dissections of human remains but often presented on the subject of animal anatomy and comparative anatomy, describing the processes of vivisections in some detail (Kausmally 2009).

This did not mean that animals used for anatomical studies were accepted by the general public, and prior to the main vivisection debate in the 1870s, following the publications of Darwin's *Origin of Species*, many well-known gentlemen publicly condemned such practice, including Joseph Addison, Alexander Pope and Samuel Johnson. Even Darwin himself expressed some resent and opposed to vivisections carried out 'for mere damable and detestable curiosity' (Preece 2003, 411–12).

The purpose of this chapter is to establish whether the faunal remains from Worcester Royal Infirmary represent animals used for anatomical study. Only those animal bones that exhibited cut marks are the subject of analysis here; unmodified bones were retained at Worcester.

Methods

Identification of species was made using the modern comparative collection at the Institute of Archaeology, University College London. Recording of the remains followed guidelines by O'Connor (2000). Ageing of animals were estimated based on studies by Silver (1969).

Results

A total of 20 individual bones were recorded the majority less than 20% complete. The preservation of the bones was poor with a porous bleached surface. The bones were uncovered from three contexts (5000, 5003 and 5008), with the largest proportion recovered from 5003 at 75%. Due to the small sample size and the fragmented nature of the deposits the contexts have in the instant been recorded as a single event.

The species uncovered at Worcester Royal Infirmary were species, considered to be typical of a domestic refuse assemblage. The body parts represented were very limited represented by mainly neck, front limb and pelvis (Table 19).

The only two species of positive identification were cattle and sheep/goat. The cattle were represented by one young animal with an unfused iliac crest aged less than 7–10 months and one fully fused innominate providing an age of more than seven months. One fully fused humeral head suggested an age of above 42–8 months. Based on these ages the cattle fragments represented at least two animals. The sheep/goat was represented by a pubic symphysis suggesting an age of less than 6–10 months.

to previous view

Element	Cattle	Sheep/ goat	Large mammal	Medium mammal
Skull/teeth	0	0	0	0
Cervical	0	0	5	0
Thoracic	0	0	0	0
Lumbar	0	0	0	0
Caudal	0	0	0	0
Vertebrae	0	0	0	0
Scapula	0	0	1	1
Sternum	0	0	0	0
Rib	0	0	0	4
Scapula	0	0	1	0
Humerus	1	0	0	1
Radius	0	0	0	0
Ulna	0	0	0	0
Feet	0	0	3	0
Pelvis	2	1	0	0
Femur	0	0	0	0
Tibia	0	0	0	0
Fibula	0	0	0	0
Total	***3***	***1***	***10***	***6***

Table 19: Identification of faunal elements (NISP)

Comparing the Worcester Royal Infirmary assemblage to that other faunal remains uncovered archaeologically from medical establishments, it is apparent that the species represented at Worcester Royal Infirmary are more typical of domestic refuse than remains of anatomical investigations (Table 20). The other sites exhibited a relative high level of animals such as dog and cat, whilst Worcester Royal Infirmary did not have any of these species represented. In general the species on the other sites were more ‘exotic’ and included examples not generally associated with consumption.

go to next page

to previous view

	Worcester Royal Infirmary			Craven Street Anatomy School			Medical College Georgia			Ashmolean Museum Oxford		
	NISP	MNI	NISP %	NISP	MNI	NISP %	NISP	MNI	NISP %	NISP	MNI	NISP %
Bird	0	0	0.0	457	11	30.6	80	7	26.9	8	n/a	0.9
Fish	0	0	0.0	118	4	7.9	0	0	0.0	1	n/a	0.1
Cat	0	0	0.0	279	3	18.7	15	2	5.1	9	3	1.1
Dog/fox	0	0	0.0	272	3	18.2	20	2	6.7	632	24	74.2
Sheep/goat	1	1	5.0	88	2	5.9	6	n/a	2.0	38	n/a	4.5
Rabbit	0	0	0.0	4	2	0.3	4	n/a	1.3	1	n/a	0.1
Cattle	3	2	15.0	7	1	0.5	36	n/a	12.1	35	n/a	4.1
Pig	0	0	0.0	3	1	0.2	6	n/a	2.0	3	n/a	0.4
Horse	0	0	0.0	3	1	0.2	0	n/a	0.0	11	n/a	1.3
Deer	0	0	0.0	0	0	0.0	2	1	0.7	0	n/a	0.0
Turtle (reptile)	0	0	0.0	50	1	3.3	3	n/a	1.0	0	n/a	0.0
Seal	0	0	0.0	1	1	0.1	0	n/a	0.0	0	n/a	0.0
Shell	0	0	0.0	0	0	0.0	8	n/a	2.7	0	n/a	0.0
Large mammal	9	n/a	45.0	11	n/a	0.7	0	n/a	0.0	30	n/a	3.5
Medium mammal	7	n/a	35.0	103	n/a	6.9	65	n/a	21.9	84	n/a	9.9
Small mammal (rodent)	0	0	0.0	89	n/a	6.0	14	n/a	4.7	0	n/a	0.0
Unknown	0	0	0.0	8	n/a	0.5	36	n/a	12.1	0	n/a	0.0
Total	***20***	***3***		***1493***	***30***		***297***			***852***		

Table 20: Faunal species representation from Worcester Royal Infirmary and comparative medical establishments

go to next page

Discussion

The recovery of human remains in association with voluntary hospitals of the late Georgian and Victorian period is commonplace, often associated with designated burial grounds, though no records of such exist for Worcester Infirmary (Mercian Archaeology 2005). Voluntary hospitals, such as the Infirmary, formed not only centres of treatment for the lower classes but also seats of medical research. During the 19th century, a main aim of medical research was to establish the causes of disease through correlating symptoms of disease with physical lesions (Reiser 1978), whereby anatomical dissection became a principal resource for scientific observation. The history of obtaining human bodies for anatomical study is fraught with tensions between the increasing requirement for study material, dictated by the exponential growth of understanding and experimentation in medicine, and the social mores regarding the sanctity of the corpse of the newly deceased.

In the late 18th and 19th century more bodies were available legally than in previous periods due to the 1752 Act of Parliament for 'better preventing the horrid crime of murder' (Richardson 1988, 36) where judges were awarded a discretionary right to substitute dissection for gibbeting in chains as part of capital punishment. The demand for bodies far outstripped the numbers provided from this source, however. Turberville (1852, 144–9), for example, records only five executions for murder at the county gaol in Worcestershire between 1800 and 1832. For this reason, grave-robbing by 'resurrectionists', whilst being illegal, was openly and regularly exploited by teaching hospitals and private anatomy schools. Perpetrators of 'burkeing' were rarely punished since the human body cannot legally be classified as property, and hence no crime of 'theft' was actually committed. Bodies became viable commercial assets and big business, being transported from many provincial cities hundreds of miles from their final destination; as exemplified by a case in Hereford in 1832 where the naked body of an army veteran William Hardman was delivered to the local coach office in a hamper (Richardson 1988, 87). A change in case law at Lancaster Spring Assizes in 1828, where he presiding judge ruled that the act of exhumation for the purposes of dissection itself was in fact illegal, resulted in the condemnation of the perpetrators and by association the surgeon anatomists. At the same time, the growing public distrust of the medical profession led to many riots nationwide; a riot in Aberdeen was sparked by the findings of human remains dumped in the backyard of an anatomy school. The public outrage at the licentious procurement and treatment of bodies culminated in Warburton's Anatomy Act of 1832. One of the conditions of the act was that dissected bodies should be given a decent Christian burial. However, the Act fell silent, as does the current Human Tissue Act (2004), regarding the treatment of previously removed organs and skeletal teaching specimens.

Several authorities in Worcester at this time were active in campaigning for the rights of the poor. There were still many misgivings regarding the act as seen from the remonstrations by the Worcester Political Union (1832, after Richardson 1988, 359) due to the fact that the new legal source of remains was unclaimed bodies of paupers from the local poor houses. Their petition highlighted the possibility of corrupt officials from workhouses easily exploiting the new system to profit from the bodies of the poor. Many inmates of the workhouse were aghast at the prospect of their remains being used for dissection. A letter from one Worcestershire inmate was published in the Lancet in 1829, when the first Anatomy Act bill was entered, declaring that having been of property he was only admitted to the workhouse through a series of tragic events that had left him without relatives or finances and that he 'looked with horror upon being classed with and treated like a murderer'

(Richardson 1988, 178). Keen to advocate the fair treatment of inmates, the Worcester Council of the Provincial Association also raised a Petition on Poor-Law Medical Relief (1842) to parliament in the hope of abolishing the employment of quacks as medical officers in workhouses, and to petition for an increases in financial support for medical treatment of the sick poor (Worcester Council of the Provincial Association 1842, 381).

The necessities and practicalities of obtaining human teaching material was not overlooked by the Worcester Medical and Surgical Society; in 1827, when a felon was heavily fined for exhumating a corpse in Exeter, the society, chaired by Hastings, 'voted a sum of 10 guineas to this surgeon in testimony of the deep feelings of sorrow with which the society are impressed that so severe a sentence should have been inflicted upon him for having exhumed a body for the purpose of teaching the anatomical art' (McMenemey 1959, 53). However, they had also remonstrated against the magistrate's decision to build the new prison gallows opposite the hospital in 1805 when the governors represented 'the great impropriety of the situation as regards to the Infirmary' (McMenemey 1959, 52). Clearly, the society sought to absolve the medical practice from such undignified acts as body snatching and to sever the association with criminality in order to promote medicine as an established reputable profession. To this end, in 1830, the Society renewed its application to Parliament to seek ways in which to obtain bodies for dissection legally, following the dissection of a murderer who had swallowed blanket material in order to cheat the gallows (McMenemey 1959, 70). Prior to the Anatomy Act of 1832, however, compromises had to be made in order to maintain high standards medical teaching and research and the Society made it quite plain that the surgeons should not be culpable of their involvement in such cases.

The legality of the remains found at the Worcester Royal Infirmary is debatable; only hospital waste and disposal of old teaching specimens would be legally disposed of here. Even after 1832, when bodies could be procured and dissected legally, it was a requirement of the new Anatomy Act that bodies should receive a decent Christian burial. Whilst it was intended that freshly removed and dissected body parts should have been covered by the Act also, in fact this was something of a grey area and hence in London, the trade in body parts was much more prevalent than bodies (Hurren 2010). The remains analysed here, primarily formed a collection of hospital waste, reflecting the high level of infectious disease that the hospital was historically documented as treating, as well as the limited methods available for treating such infection at the time. Some elements demonstrated evidence of being stained, wired and mounted as teaching models and others had been dyed. Nonetheless, a substantial number of bisections were observed that were clearly not therapeutic in origin. Thus, it appears that a considerable proportion of the remains were subject to anatomical investigation. However, the overall number of remains present is smaller than other contemporary institutions, which may be an indication that the scale of such undertakings was more moderate, although caution should be exercised given the limitations of the survival of archaeological deposits.

to previous view

Conclusion

The watching brief at the site of the Worcester Royal Infirmary led to the recovery of an assemblage of 1828 disarticulated human skeletal elements. Analysis of the remains confirmed the presence of a high prevalence of infectious disease and numerous bisections, interpreted as representing amputations carried out in order to treat infected limbs. Tibiae were particularly affected. Most cases were diagnosed as non-specific but five cases of suspected syphilis as well as two cases of tuberculosis of the hip were identified, diseases that were not recorded in the skeletal assemblage contemporary churchyard of St Andrew's, Worcester. The analysis also showed higher rates of rib lesions at the Infirmary, indicating that chest diseases such as pleural tuberculosis, were more prevalent here. In addition, several examples of peri-mortem trauma were also identified. The demographic analysis indicates that both children and adults were present in the assemblage, and whilst both females and males were represented, a significant bias towards males was observed.

In addition to therapeutic amputations, a considerable number of other bisections and defleshing marks were observed. Also present were elements that had been stained and wire mounted. These indicate that anatomical dissection was undertaken as part of medical research and teaching at the Infirmary. A small number of faunal elements were also recovered but these exhibited no evidence of anatomical dissection. The deposits of remains are currently only broadly dated and, therefore, it is difficult to speculate as to the legal status of the acquirement and disposal of the human remains at the time. The archaeological evidence does suggest, however, that separate depositional events relate not only to mode of surgical intervention to the skeletal elements, but also the retention of different body parts for longer periods of time. Only through the bio-archaeological analysis of such deposits and the tangible evidence this provides can an insight be gained into the physical realities of an evolving medical practice during the post-medieval period.

The human remains from the Worcester Royal Infirmary constitute the largest skeletal assemblage reported to date associated with a post-medieval provincial hospital. Their analysis has provided a unique source of direct evidence for surgical intervention and anatomical dissection that will be invaluable for comparison with contemporary assemblages from larger hospital collections.

go to next page

to previous view

Acknowledgements

Osteological analysis and report writing were carried out by Gaynor Western and Tania Kausmally of Ossafreelance. Thanks are due to Simon Woodiwiss (project details), Liz Pearson (environmental archaeology), Simon Sworn (site details) and C Jane Evans (artefacts), of Worcestershire Archive and Archaeology Service (Worcestershire County Council), as well as Natasha Powers (MoLA) and Jelena Bekvalac of the Centre for Human Bioarchaeology, Museum of London for her excellent radiographic services.

go to next page

to previous view

Bibliography

Aufderheide, A C and Rodriguez-Martin, C, 1998 *The Cambridge encyclopedia of human palaeopathology.* Cambridge: Cambridge University Press

Barnes, E, 1994 *Developmental defects of the axial skeleton in paleopathology.* Colarado: University Press of Colorado

Bartrip, P W J, 2003 *The Home Office and the dangerous trades; regulating occupational disease in Victorian and Edwardian Britain.* London: Editions Rodolpi B V

Bass, W M, 1995 *Human osteology; a laboratory and field manual*. Columbia: Missouri Archaeological Society

Bell, B, 1791 *A system of surgery.* Edinburgh: Bell and Bradfute

Boulter, S, Robertson D and Start, H, 1998 The Newcastle Infirmary at the Forth, Newcastle upon Tyne. Unpublished skeletal report, ARCUS

Blakely, R L and Harrington, J M, 1997 *Bones in the basement – Post-mortem racism in 19th century medical training.* Washington and London: Smithsonian Institution Press

Brickley, M, Berry, H and Western, A G, 2006 The people: Physical anthropology, in M Brickley, S Buteux, J Adams and R Cherrington *St Martin's uncovered: Investigations in the churchyard of St Martin's-in-the-Bull Ring, Birmingham*, 90–151. Oxford: Oxbow Books

Brickley, M and McKinley, J I (eds), 2004 *Guidelines to the standards for recording human remains. IFA paper no 7.* Southampton and Reading: BABAO and Institute of Field Archaeologists

Brickley, M and Ives, R, 2002 Draft report on the human bone from the Zion Chapel burial ground, Hereford. Unpublished report, Archenfield Archaeology

Brooks, S T and Suchey, J M, 1990 Skeletal age determination based on the os pubis: A comparison of the Acsadi-Nemeskeri and Suchey-Brooks methods, *Human Evolution,* **5**, 227–38

Buikstra, J E and Ubelaker, D H, 1994 *Standards for data collection from human skeletal remains* Arkansas Archaeological Survey Research Series **44**. Fayetteville, Arkansas: Arkansas Archaeological Survey

Carden, H, 1864 On amputation by single flap, *British Medical Journal,* 416–21

Cowie, R, Bekvalac, J and Kausmally, T, 2008 Late 17th to 19th century burial and earlier occupation at All Saints, Chelsea Old Church, Royal Borough of Kensington and Chelsea. MOLAS Archaeology Studies Series **18**

Draper, J, 1984 *Post-medieval pottery 1650–1800*. Oxford: Shire Archaeology

English Heritage, 2002 *Human bones from archaeological sites: Guidelines for producing assessment documents and analytical reports*. London: English Heritage, Centre for Archaeology Guidelines

Hastings, C, 1827 On the peculiarly soft state of the structure of the lungs, *Edinburgh Journal of Medical Science,* **5 (**3), 1–21

Hastings, C, 1841 Worcester Infirmary. A report of cases attended at this hospital, *Provincial Medical Surgery Journal*, **1 (**1), no 21, 342–4

Hastings, C, 1855 Facts illustrative of cerebral pathology, *Journal of the Provincial Medical and Surgery Association,* **145**, 925–8

Henderson, J, 1987 Factors determining the state of preservation of human remains, in A Boddington, A N Garland, and R C Janaway (eds) *Death, decay and reconstruction: Approaches to archaeology and forensic science*. Manchester: Manchester University Press

go to next page

Hicks, R, 2006 *Health: Silicosis*. Available: http://www.bbc.co.uk/health Accessed: June 2010

Holden, L, 1851 *A Manual of the dissection of the human body.* London; Highley and Son

Homan, P T, 2003 *Information sheet 12. Dispensary bottles.* London: Royal Pharmaceutical Society. Available: http://www.rpharms.com/museum-pdfs/12-dispensary-bottles.pdf Accessed: 30 September 2014

Hull, G, 2003 The excavation and analysis of an 18th century deposit of anatomical remains and chemical apparatus from the rear of the first Ashmolean Museum (now the Museum of History of Science), Broad Street, Oxford, *Post-Medieval Archaeology,* **37**, 1–28

Hurren, E T, 2010 Dissecting London's poor: Anatomy and autopsy at St Bartholomew's Hospital, London *c* 1832 to 1929. Unpublished lecture. Cambridge

Kausmally, T, 2009 *William Hewson and the Craven Street Anatomy School – A private anatomy school in the 18th century.* Unpublished PhD upgrade document, Institute of Archaeology, University College London

Kirkup, J, 2007 *A history of limb amputation*. London: Springer

Klein, R G and Cruz-Urbine, K, 1984 *The analysis of animal bones from archaeological sites,* Prehistoric Archaeology and Ecology Series. Chicago and London: The University of Chicago Press

Liston, R, 1838 *Practical surgery.* Philidelphia: James Crissy

Lovejoy, C, Meindl, T, Pryzbeck, T and Mensforth, R, 1985 Chronological metamorphosis of the auricular surface of the ilium: A new method for the determination of age at death, *American Journal of Physical Anthropology,* **68**, 15–28

McMenemey, W H, 1947 *A history of the Worcester Royal Infirmary*. London: Press Alliances Ltd

McMenemey, W H, 1959 *The life and times of Charles Hastings, founder of the British Medical Association*. Edinburgh: E and S Livingstone Ltd

McMenemey, W H, 1966 Charles Hastings (1794–1866): Founder of the British Medical Association. *British Medical Journal,* **1**, 937–42

Mays, S, Fysh, E and Taylor, G M, 2002 Investigation of the link between visceral surface rib lesions and tuberculosis in a medieval skeletal series from England using ancient DNA, *American Journal of Physical Anthropology,* **119**, 27–36

MedPix, 2010 *Pleural califications*. Available: http://rad.usuhs.edu/medpix/new_topic.html?mode=single&recnum=4415&table=card&srchstr=Asbestosis&search=Asbestosis Accessed: 30 September 2014

Mercian Archaeology, 2005 Desk-based assessment and buildings assessment of the site of the former Royal Infirmary, Castle Street, Worcester. Unpublished report, Mercian Archaeology and Historic Buildings, PJ 04/126

Murphy, C, 2010 A study of the human remains excavated from the Old Anatomy School (1711-1825). Phd thesis, Trinity College Dublin

O'Connor, T, 2000 *The archaeology of animal bones.* Stroud: Sutton Publishing

Ogden, A, 2003 Skeletal report for the Tallow Hill excavation. Unpublished report, Department of Archaeological Sciences, University of Bradford

Ortner, D J, 2003 *Identification of pathological conditions in human skeletal remains.* Washington: Academic Press, Smithsonian Institution

Powers, N, 2009 The human bone, in J Vuolteenaho, L Wood and N Powers, *Royal London Hospital, Whitechapel Road, London E1, post-excavation assessment*. Unpublished report: Museum of London Archaeology

Preece, R, 2003 Darwinism, christianity, and the great vivisection debate, *Journal of the History of Ideas*, **64**, 399–419

Provincial Practice of Medicine and Surgery, 1860 Statistical report of the principal operations performed during the year 1859, *Medical and Surgical Practice*, **1,** 446–9

Reichs, K J, 1998 Post-mortem dismemberment: Recovery, analysis and interpretation, in K Reichs (ed) *Forensic osteology: Advances in the identification of human remains (2nd edn)*. Springfield: Charles C Thomas, 353–88

Reiser, S J, 1978 *Medicine and the reign of technology*. Cambridge: Cambridge University Press

Richardson, R, 1988 *Death, dissection and the destitute.* London: Phoenix Press

Roberts, C, Boylston, A, Buckley, L, Chamberlain, A C and Murphy, E M, 1998 Rib lesions and tuberculosis: The palaeopathological evidence, *Tubercle and Lung Disease,* **79** (1), 55–60

Roberts, C and Cox, M, 2003 *Health and disease in Britain from prehistory to the present day*. Stroud: Sutton Publishing Ltd

Roberts, C and Manchester, K, 1997 *The archaeology of disease*. Stroud: Sutton Publishing Ltd

Roy, S, 2010 *Pericardial disease*. Available: http://www.histopathology-india.net/pericard.htm Accessed: 30 September 2014

Scheuer, L and Black, S, 2004 *The juvenile skeleton.* London: Elsevier Academic Press

Salter, R, 1999 *Textbook of disorders and injuries of the musculoskeletal system* (3rd edn). Maryland: Williams and Wilkins

Seetha, K, 2000 *The importance of cut placement and implement signatures to butchery interpretation*. Unpublished thesis, University of Cambridge

Silver, S, 1969 The aging of domestic animals, in D Brothwell and E Higgs *Science and archaeology*. London: Thames and Hudson 283–302

Swete, H, 1882 Hospital sanitation exemplified in the history of the Worcester Infirmary, from 1754 to the present date. *British Medical Journal,* **2**, no 1134 (Sep 23), 563–5

Symes, J, 1855a Lectures of clinical surgery delivered during the winter session of 1854–5. Lecture XII Amputation of the ankle, *The Lancet,* March 24, 307–8

Symes, J, 1855b Lectures of clinical surgery delivered during the winter session of 1854–5. Lecture XIII Amputation of the thigh. *The Lancet,* March 31, 333–5

Thompson, C, 1868 *Clinical lectures of diseases of the urinary organs*

Trotter, M, 1970 Estimation of stature from intact limb bones, in T D Stewart (ed) *Personal identification in mass disasters*. Washington: Smithsonian Institution, 71–83

Turberville, T C, 1852 Worcestershire in the 19th century: *A complete digest of facts occuring in the County since the commencement of the year 1800*. London: Longman, Brown, Green, Longman's

Vigorita, V J, 2008 *Orthopaedic pathology* (2nd edn). London: Wolters Luwer/Lippincott Williams and Wilkins

Virchow, R, 1880 *A description and explanation of the method of performing post-mortem examinations in the dead-House of the Berlin Charité Hospital, with especial reference to medico-legal practice, from Charit-Annalem* Translated by T. P. Smith Oxford: Churchill

Western, A G, 2006 Analysis of the human remains from St Andrew's burial ground, Worcester. Unpublished report: Ossafreelance, project OGW1011

Witkin, A, 1997 The cutting edge: Aspects of amputations in the late 18th and early 19th century. Unpublished MSc Dissertation, University of Sheffield and Bradford

Wood, E, 1872 Amputation at the knee joint, *The Boston Medical and Surgical Journal*, **86**, 1–5

Worcester Council of the Provincial Association, 1842 Petition on Poor-Law medical relief. *Provincial Medical Surgery Journal,* **S1–3**: 381–2

WRINL, 2002 *Dr Wall and the early years of Worcester Infirmary*. Available www.wrinl.org.uk . Accessed: 2010

The archive (artefacts, human remains and records) has been placed with Worcester City Museums.

Published by

Worcestershire
Archive & Archaeology Service

www.explorethepast.co.uk/

worcestershire
county council