Demography, diet and state of health in Roman York

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Abstract

This study combines new and pre-existing osteological evidence with archaeological evidence in order to reconstruct the demographic composition, broad dietary patterns and health status of the population of Roman York. This research examines the composition of the military and civilian sectors of the population, dietary patterns inferred from the study of dental remains, and differences in health according to social and occupational status categories within the population.

Results indicate that the population had significant male bias, under-representation of infants and sub-adults, and approximately equal male and female life expectancy. Diets are likely to have been rich in fat and protein, and low in both cariogenic foods and foods that provide vitamins. Compared to contemporary urban sites, York had significantly elevated prevalence of ante-mortem trauma and porotic hyperostosis. Comparatively high rates of dislocation, peri-mortem trauma, brucellosis, osteopenia, os acromiale and osteochondroma were also observed.

These findings suggest that the demographic composition of the population is heavily influenced by the presence of the military. A combination of osteological, isotopic, archaeobotanical, zooarchaeological and literary evidence indicates that dietary staples in the town appear to have been spelt based products such as bread, and beef. Other dietary components are likely to have included dairy products such as sheep's milk and cheese, olive oil, dried figs and fish. It is also likely that the populace were consuming lesser quantities of sugary products (e.g. containing honey and syrup), and fresh fruit and vegetables than populations from contemporary towns. Some of the observed pathological conditions with elevated values at Eboracum may be the result of poor comparative data, osteological rarity of a condition, or a combination of complex causal factors. Elevated prevalence of traumatic injury in some skeletal elements of the cranium and several post-cranial skeletal elements was significantly associated with an unusual group of burials from sites located on Driffield Terrace.

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Chapter 1: Introduction

The composition of a population provides a framework within which we can examine and interpret health status and population behaviour. The way in which a population functions (e.g. action *within* and reaction *to* the physical environment) is affected by, and also influences, health and diet. Diet is intrinsically linked to health status, and each of these factors has the power to affect and change the character of the other. Human osteoarchaeology is an important tool with which we can study these topics in relation to past populations.

The purpose of this study is to investigate the aforementioned parameters in regards to the Roman population of the city of York in the north of England. There are very few contemporary literary accounts relating to the people of Roman York. The vast majority of evidence for human activity pertaining to the Roman period in York is archaeological and structural. Therefore, the archaeological record is our primary means of investigating the town and its population during this time period.

The main aim of this study is to combine new and pre-existing osteological evidence with archaeological evidence in order to reconstruct the demographic composition, broad dietary patterns and health status of the population of Roman York. Key research questions to be addressed in this project are:

1. What was the demographic composition and size of the military and civilian sectors of the population?
2. What can be inferred about diet in Roman York from the study of the dental remains, do dietary patterns change through time, and how does diet in York compare with data from Roman period cemeteries elsewhere in Britain?
3. What was the health status of the population, and are differences discernible between social and occupational status categories within the population?

1.1. Current State of Knowledge: The People of Roman York

The establishment (in the first century A. D.) of a Roman legionary fortress at *Eboracum* (present-day York) was followed by the development of a civilian settlement (sometimes referred to as the *canabae*). In the early third century A. D., the town was given official *colonia* status, which also gave the inhabitants of the town Roman citizenship (Ottaway, 2004). Both the military and civilian population of *Eboracum* was served by a variety of large and small cemeteries distributed around the approach roads principally to the north, south-east and south-west of the fortress (RCHME, 1962: 67; Jones, 1984: 34). Burials in all cemeteries are represented by inhumations and cremations, spanning the full period of Roman occupation from the first to the fourth centuries A. D. and including the remains of both military and civilian personnel.

Archaeological work over the last 250 years has steadily added to our understanding of York during the Roman period. The increasing frequency of commercial archaeological excavation and subsequent post-excavation work conducted over the last 50 years has yielded numerous piecemeal discoveries, including isolated individual burials, small groups of burials and other disarticulated human skeletal material. More than half of the archaeological excavations that have produced human remains of Roman date have taken place within the last 25 years. While many of these excavations have been small in spatial extent, when the assemblages are aggregated they constitute a large and important skeletal sample.

A database of archaeological sites in York yielding human skeletal remains (compiled by Claire Rawlings in 2007 on behalf of York Osteoarchaeology Ltd.) contains 57 entries for excavations of Roman burial sites, from which came 567 discrete inhumations, as well as 16 assemblages of cremated bone, and there were also numerous contexts containing unburnt disarticulated bone. Many more cremation burials are known to have been found in earlier excavations but the cremated bone was apparently not retained. According to this database, the skeletal remains from under half of the sites have been subject to osteological analysis, with five sites analysed to assessment level (producing factual data about the skeletal material, and establishing whether the material requires further, in depth study), and 14 sites being subject to full, comprehensive osteological analysis. Since this database was compiled additional discoveries and excavations of Roman period burials have been made in York.

Only two studies of large assemblages from Roman York have been conducted: these have discussed Trentholme Drive (Wenham, 1968) and Driffield Terrace (in press). The largest extant and published assemblage of 342 discrete skeletons is from the excavation carried out in 1959 at Trentholme Drive, which sampled a small part of the extensive Mount cemetery located alongside the road leading southwest from the Roman fortress (RCHME 1962: 92-107). Osteological and dental reports on this skeletal assemblage were published more than 40 years ago (Cooke and Rowbotham, 1968; Warwick, 1968). Stable isotopic analyses of some of the skeletal remains from Trentholme Drive have been published very recently (Müldner & Richards, 2007; Leach *et al.*, 2009). Re-analysis of a large sample of the assemblage was also conducted in 2009 by Joshua Peck of Ohio State University as part of a doctoral thesis, revealing that some of the results from the original assessment do not match results gained using modern methodologies. Despite this recent work, the skeletal material still requires fuller reappraisal using modern standard recording systems, in order to make the data fully compatible with those from other contemporary osteological reports. An additional 83 skeletons were excavated 200m to the north of Trentholme Drive at Driffield Terrace from 2003-2005: the results of these excavations are currently in the final stages of publication by York Archaeological Trust. This group, together with other finds from the surrounding Mount cemetery area can provide a more complete picture of the population served by this particular cemetery. All this material will also be included in the present study.

Smaller quantities of skeletal material are available from many other Roman cemetery areas in and around York, providing a view of the wider population. Although many of these assemblages have been reported on in the “grey literature” (which comprises an extensive body of work, including but not limited to unpublished archaeological site reports and specialist finds reports, and which are freely available at local Historic Environment Records offices and Sites and

Monuments Records), very few have been published, and no attempts have been made to combine data from multiple sites. Furthermore, the current whereabouts of several of these assemblages are presently unknown. The availability of this combined human skeletal resource provides an opportunity to reconstruct the demographic composition, diet, and state of health of the inhabitants of an important urban centre.

This type of study, combining published and unpublished osteological data, has never been attempted for a Romano-British town. Small quantities of human skeletal material (from this and and other time periods) are rarely considered for in depth study because they are highly likely to be unrepresentative of the wider population. Larger, published assemblages tend to concentrate on material from a single site or excavation area, usually because resources (e.g. time, funding, and limitations of the research questions) do not permit inclusion of material from outside the specified geographic area of focus. Although findings from larger burial assemblages and cemetery sites can be extrapolated into interpretations about the whole associated town, even these have the potential to be biased (e.g. towards certain sections of society, a particular burial method, use during a particular time period). Incorporation of all accessible data for one town means that we can monitor any differences that occur between burials both temporally and spatially, and be confident that the information comes from a much more representative cross section of the original population. York is a good case with which to try this type of study, as there is a large corpus of human skeletal data available, the town has been excavated extensively on all sides (so data comes from a good range of burial locations), and, as the next section of this chapter and Chapter 2 will illustrate, the town was of crucial importance (particularly to the military) and had significant status in Roman Britain.

1.2. Researching the Populations of Roman Britain

In order to fully understand why the present study is necessary, and why York is an excellent case to use for this type of study, this section will outline the current state of knowledge in regards to skeletal assemblages from Romano-British urban sites. There has been very little in the way of comprehensive osteological study of populations from Romano-British urban centres, particularly in the north of England. As well as York, archaeological and historical evidence has suggested that there were a number of other substantial urban centres in Roman Britain. These are listed in Table 1.1. Like York, many of these towns also had a military presence.

Modern Settlement Name	**Roman Settlement Name**	**County**
Aldborough	*Isurium Brigantum*	North Yorkshire
Brough-on-Humber	*Petuaria*	East Riding of Yorkshire
Caerleon	*Isca Augusta*	Monmouthshire
Caerwent	*Venta Silurum*	Monmouthshire
Caistor-by-Norwich	*Venta Icenorum*	Norfolk
Canterbury	*Durovernum Cantiacorum*	Kent
Carlisle	*Luguvalium*	Cumbria
Carmarthen	*Moridunum*	Dyfed
Chester	*Deva Victrix*	Cheshire
Chichester	*Noviomagus Reginorum*	West Sussex
Cirencester	*Corinium Dobunnorum*	Gloucestershire
Gloucester	*Glevum Colonia*	Gloucestershire
Colchester	*Camulodunum*	Essex
Dorchester	*Durnovaria*	Dorset
Exeter	*Isca Dumnoniorum*	Devon
Leicester	*Ratae Corieltauvorum*	Leicestershire
Lincoln	*Lindum Colonia*	Lincolnshire
London	*Londinium*	Greater London
Silchester	*Calleva Atrebatum*	Hampshire
Winchester	*Venta Belgarum*	Hampshire
St. Alban’s	*Verulamium*	Hertfordshire
Wroxeter	*Viroconium Cornoviorum*	Shropshire

Table 1.1: The main settlements of Roman Britain (Mattingly, 2007: 262)

Some of the aforementioned urban centres have produced very little in the way of human skeletal material. No known examples of burial sites dating to the Romano-British period have been found associated with the Roman *civitas* (see page 67-8 of this study for definition of the various Roman settlement statuses) at Aldborough, and archaeological work has chiefly focussed on areas of the town defences (De la Bédoyère, 2003: 95). It is thought that a cemetery may exist to the south of the town at Boroughbridge (Monument No. 55226), but this is currently unverified (Pastscape, 2010a and 2013a). Similarly, although a cemetery of Roman date was thought to exist to the west of the modern town of (Caistor-by-)

Norwich, excavations at the West Norwich Hospital site in 1994 ascertained that the majority of the Roman site had been destroyed by nineteenth-century quarrying (Burnham *et al.*, 1995: 356). Although the site is reported to have contained lead coffins, it is not clear whether these were reported during the 1994 archaeological intervention or during earlier quarrying.

Several sites have only yielded very small human skeletal assemblages. A small number of burials have been found associated with the *civitas* at Brough-on-Humber. These include an inhumation burial (NMR 629337) found in the early twentieth century (Archaeology Data Service, 2013a), four burials excavated by York Archaeological Trust (Hunter-Mann *et al.*, 2000), and one burial excavated by Northern Archaeological Associates in 1997 (Mackey, 1997). Only a small quantity of human skeletal remains has been found associated with the *civitas* at Caerwent. This comprises one burial dating tentatively to the late Roman period (Archaeology Data Service, 2013b) and bones found during a Time Team excavation in 2008 (Telegraph Media Group, 2008). Only one cremation burial has been discovered at Carmarthen, in 2001 (Crane, 2001), and only three burials have ever been found associated with the *civitas* at Exeter (Archaeology Data Service, 2013h; Pastscape, 2013e).

While late eighteenth and early nineteenth century excavations near the *civitates* of Silchester and Wroxeter discovered cemeteries (both to the east of the town), it is unknown how much of the human skeletal material was retained, or where it currently resides (Archaeology Data Service, 2013i and 2013j; Pastscape, 2013f). A handful of cremation burials have otherwise been found associated with Silchester (Goodburn *et al.*, 1976: 368; Grew *et al.*, 1980: 394-5). Similarly, other discoveries at Wroxeter have mainly comprised a few poorly preserved inhumation burials and several cremation burials (Archaeology Data Service, 2013k).

Although a substantial-second century inhumation cemetery was identified on the west side of Chester in the late nineteenth and early twentieth century, the cemetery was not excavated in full, and it is unclear how much, if any of the skeletal material was ever retained (Collingwood and Richmond, 1969: 166;

Pastscape, 1999b; Archaeology Data Service, 2013c). The majority of known human skeletal discoveries listed in archaeological and heritage databases are few and piecemeal. For example, two cremation burials were found in 1870 at Cherry Grove on the east side of Chester (Pastscape, 2013c). Little other human skeletal material has been found at Chester dating to this period.

A moderate number of Romano-British burials have been found associated with the *civitas* at Leicester and the *colonia* at Lincoln. However, these are mostly found individually or in small clusters across multiple sites. Excavations in the 1920's at Leicester uncovered several areas of a Roman cemetery (Dare, 1927), although analysis focussed primarily on finds such as pottery rather than the human remains. Other excavations at Leicester discovering small clusters of Roman burials have mainly taken place since the 1970s, at sites located on almost all sides of the city (Burnham *et al.*, 1993: 290; Burnham *et al.*, 1994: 271; Higgins and Cooper, 1997: 93; Gossip, 1998: 159-60; O'Brien and Crank, 2001; Derrick, 2002; Archaeology Data Service, 2013l). The majority of known burials at Lincoln seem to have been discovered since the 1990's, again on almost all sides of the city (McDaid and Field, 1995; Wragg, 1995; Wragg, 1996; Keppie *et al.*, 1998: 392; Mudd and Lewis, 2004).

Larger quantities of human skeletal material dating to the Romano-British period have been found at Caerleon, Carlisle, and Chichester. Exactly 121 discrete mid-first- to late second-century cremation burials were excavated at the Caerleon Lodge Hill cemetery in 1992 (Evans *et al.*, 1997). Other Roman burials associated with this town are isolated examples, e.g. one cremation burial had previously been found on the same site in 1909 (Evans *et al.*, 1997: 169) and one Roman "pipe burial" (where a pipe was laid into the grave, through which libations could be poured from ground level by mourners visiting the deceased) found in 1927 (Wheeler, 1929; Philpott, 1991: 28). The *civitas* at Carlisle has two principal sites that have yielded Romano-British human skeletal remains. Grave monuments and furniture, as well as more than 30 cremation and inhumation burials dating up to the fifth century have been found on the main road leading south east out of the town since the nineteenth century (Pastscape, 1999a). Additional excavation at Botchergate in Carlisle, Cumbria, in 1998 revealed further second- to third-century cremation burials (Keppie *et al.*, 1999: 333). These findings have led to the belief that *Luguvalium's* main cemetery was centred on the south east road (Pastscape, 1999a). At Chichester, one of the largest assemblages was excavated in the mid-late 1980s in the grounds of the Chichester Theological College, where 62 fourth-century inhumation burials were discovered (Pastscape, 2013d). Various cemetery areas have been discovered throughout the nineteenth and twentieth centuries, although it is unknown how much of the skeletal material has been retained (Wessex Archaeology, 1997; Archaeology Data Service, 2013f and 2013g). Piecemeal discoveries have also been made in the 1990's, for example at The Hornet (Archaeology Data Service, 2013d) and on Broyle Road on the north side of the town (Archaeology Data Service, 2013e).

Probably the most significant quantities of Romano-British burials have been found at Canterbury, Cirencester, Colchester, Dorchester, Gloucester, London, St. Albans and Winchester. The most recent discovery of any discussed in this section is at Canterbury, where between 2009 and 2011, approximately 125 inhumations dating to the third to fourth century were excavated by Canterbury Archaeological Trust at Hallett's Garage, St. Dunstan's Street on the north west side of the city (Gollop, In Press.). This is by far the largest assemblage of human remains dating to the Roman period ever to be found in Canterbury. The second largest assemblage, comprising 53 third-century cremation burials were also found on the north west side of the town, on the corner of London Road and Princes Way in 1982 (Frere *et al.*, 1987; Pastscape, 2013b). Numerous other isolated and small groups of inhumation and cremation burials have been found on all sides of the town, and are largely reported in the grey literature.

The largest excavated Romano-British cemetery assemblage associated with the *civitas* at Cirencester is the Bath Gate cemetery, comprising 405 inhumation and 3 cremation burials dating to the fourth to fifth century, excavated between 1969 and 1981 (McWhirr *et al.*, 1982). Further burials were discovered at the site in 2004 (Holbrook *et al.*, 2007b). A moderate assemblage comprising 46 cremation burials and eight inhumation burials was excavated in 1960, on the south side of the town (Reece, 1962). The majority of the remaining burials from Cirencester are individual or in small clusters, and from sites mainly located on the southern and western sides of the city (Wilkinson, 1988; Pastscape, 1999c; Matthews and Bashford, 2002; Holbrook *et al.*, 2007a; Archaeology Data Service, 2013m).

Approximately 1000 Romano-British burials have been discovered at sites in and around the *colonia* at Colchester. By far the most extensive assemblage originates from the Butt Road cemetery, where 728 inhumation burials and 5 cremation burials dating from the late third to late fourth centuries were excavated from the late 1970’s to early 1980’s (Crummy *et al.*, 1993). A further 180 cremation burials have been excavated across three sites around Colchester since 1996 (Keppie *et al.,* 2001: 361-3; Orr, 2010; Archaeology Data Service, 2013n), as well as numerous finds of scattered inhumation and cremation burials made since the nineteenth century (Hall, 1944; Burnham *et al.*, 1997; Keppie *et al.*, 1998: 407; Burnham *et al.*, 2002: 325; Pastscape, 2010b; 2013h).

Several substantial assemblages have been excavated around the *civitas* at Dorchester. By far the most renowned (and largest) assemblage comes from Poundbury: 1388 Romano-British inhumation burials dating from the late second to fourth centuries were excavated here between 1966 and 1987 (Farwell and Molleson, 1993). Other large assemblages from Dorchester include Alington Avenue, which comprises 91 inhumation burials and three cremation burials (Davies *et al.*, 2002), Fordington Hill, which comprises 50 inhumation burials and two cremation burials (Archaeology Data Service, 2013o), and Little Keep which has 29 inhumation burials (Egging Dinwiddy, 2009). Smaller groups of inhumations have also been excavated at a number of other sites (Keppie *et al.*, 2001: 371; Pastscape, 2005; 2013i).

The *colonia* at Gloucester also has a relatively large burial assemblage from one area, with isolated piecemeal burials located at other sites in and around the city (Garrod, 1994: 202; Garrod, 1998: 202; Thomas, 1998: 201; Burnham *et al.*, 2002: 343; Pastscape, 2013g). The majority of Romano-British burials from Gloucester have been located on the north east side of the modern city centre, along London Road. The earliest discoveries occurred in the mid-nineteenth century, when a group of first to second century cremation burials were unearthed (Fullbrook-Leggatt, 1933: 87-8). Later discoveries along the same road have been made since the 1970s (Garrod, 1997; 1998; 1999; Pastscape, 1999d), with the most recent excavations taking place from 2004-6 and comprising 154 inhumations and 12 cremations dating from the first to fourth centuries (Simmonds *et al.*, 2008).

Copious numbers of burials and sites are associated with the Romano-British city of London. Of the three largest assemblages, 136 cremation burials and 550 inhumation burials were found on the east side of London (Barber and Bowsher, 2000), 46 inhumation burials were found to the south (MOLA Centre for Human Bioarchaeology 2009a), and 137 inhumation burials were found to the west (MOLA Centre for Human Bioarchaeology, 2009b). Together these three sites contain burials dating from the first to early fifth centuries A. D. The number of individual and groups of burials found at other sites in and around London is so extensive that it is beyond the scope of this chapter to list them all. The majority of these piecemeal burials are reported on in the grey literature, and while there is no single publication that lists or attempts to analyse all these burials, information on many of these examples is freely available on online databases such as Pastscape and Heritage Gateway. Furthermore, the Museum of London Centre for Human Bioarchaeology is constantly adding data for Roman (and other period) burials from London onto their online database, with a view to make a comprehensive dataset available to external researchers.

The majority of burials found associated with the *municipium* at St. Albans come from the King Harry Lane site, located to the south west of the town. Excavation at this site since the 1960's has revealed a total of 422 cremation burials (up until the last excavation in 1999: Burnham *et al.*, 2000: 409). Another cremation cemetery was excavated at St. Albans Abbey church in the mid-nineteenth century (Pastscape, 1999e). Smaller groups of burials have been found at Everlasting Lane to the north west of the town (Pastscape, 1999f), by the River Fosse (Pastscape, 1999g) and River Ver (Pastscape, 1999h), and just outside the town wall (Anthony, 1970: 44).

The most substantial Romano-British human skeletal assemblage from the *civitas* at Winchester comes from the Lankhills cemetery. This site was excavated from

1967 to 1972, and again from 2000 to 2005, producing a total of 751 inhumation burials and 32 cremation burials (Clarke, 1979; Booth *et al.*, 2010). Over 200 graves (including 92 cremation burials) dating to the first and second centuries A. D. were excavated at a cemetery to the north west of Winchester, as well as a third to fourth century inhumation cemetery (Pastscape, 1999i). Part of what is presumed to be the north cemetery was excavated in 1998 at Swan Lane, yielding 38 fourth century inhumations (Keppie *et al.*, 1999: 371-2). A further 20 inhumations were found nearby at Hyde Close in 1999 (Archaeology Data Service. 2013p). Smaller human skeletal assemblages have been excavated at numerous other sites around Winchester (Collis, 1978: 149-55; Pastscape, 1999j; 2013k; Birbeck, 2001; Keppie *et al.*, 2001: 376).

This site data highlights a number of things. Firstly, the majority of reports for archaeological sites (both with and without human skeletal remains) are available as grey literature. While grey literature is generally of good quality and freely available, only a small proportion is available easily online. Furthermore, it is very difficult to ascertain the exact number of sites with human skeletal remains without spending substantial amounts of time at local archives, and the relevant Historic Environment Records office. Although some site reports are available online, sometimes via well-known databases such as the Archaeology Data Service and Pastscape, different databases do not always contain the same information or site listings. Researching an exhaustive list of archaeological sites and findspots of a particular type for one city or area is therefore extremely time-consuming: presumably this is one of the reasons why a study compiling data of this sort has never been conducted before. As well as the grey literature reports, other material (particularly antiquarian finds) frequently ends up in museum store rooms, where it may or may not be found and reported on by a researcher or curator. Furthermore, museum-based finds are not always able to be listed on accessible online databases.

Another point demonstrated by the aforementioned summary of available material is that the majority of human skeletal material from Romano-British urban sites comes from sites in the south of England. Of all the principal Roman towns in Britain, York is the only one in the north of England with a burial assemblage of substantial size. Combined with the fact that there is little contemporary historical evidence pertaining to York, this serves to highlight the fact that York’s Romano-British human skeletal assemblage is a critically important source of evidence from an important urban centre in a region of Britain where osteological evidence is lacking in comparison to its southern counterparts.

1.3. The Present Project

This project intends to collate all available osteological data related to the Romano-British settlement at York. The first stage of this project required archival research to identify study material (additional to the available material already outlined at the beginning of this chapter) as well as active liaison with researchers who had projects in progress concerning the skeletal remains included in this study. A comprehensive list of relevant human skeletal material was compiled, encompassing the maximum amount of available material for the town. Once this list had been compiled, it was necessary to either locate and analyse the skeletal material, or establish whether a recent osteological report was available and obtain a copy. This approach will be discussed thoroughly in Chapter 3.

Following data acquisition, all skeletal data was organised and stored electronically prior to analysis. Inhumation burials, cremation burials and unburnt disarticulated material were tabulated separately, as a function of the necessarily differential recording methods. Where possible, data were divided into “earlier” and “later” time periods in order to ascertain any changes in observed population attributes over time. Additionally, the population was divided (where possible) into civilian and military burials, in order to facilitate analysis of the population in terms of social grouping. These approaches will also be discussed in detail in Chapter 3.

Very little in the way of osteological study has been conducted taking this approach, and no study of this type has ever been conducted for a settlement in Roman Britain. Most osteological or archaeological studies, whether doctoral, post-doctoral or otherwise, typically concentrate on one or two large assemblages, facilitating comparison between sites, time periods, age groups, social classes and so on (e.g. Farwell and Molleson, 1993; Barber and Bowsher, 2000; Simmonds *et al*., 2008). Studies of this sort may focus on either demographic composition of a population, diet or health individually or in any combination. Dietary study also tends to be the main focus of isotopic work (e.g. Müldner and Richards, 2005). The majority of broader, “assessment” style studies tend to focus on one or several cemetery sites from one settlement or area, but rarely incorporate data from nearby individual or isolated groups of burials, or disarticulated skeletal material (e.g. Bruce *et al*., in prep. focuses on one medieval cemetery site on the outskirts of York, and does not seek to incorporate data from nearby cemeteries or similar date).

Roberts and Cox’s (2003) book *Health and Disease in Britain*, takes a very broad approach in order to assess the health patterns of skeletal populations across the whole of Britain. Skeletal data from multiple sites from all over the country were utilised, and analyses undertaken according to discrete time periods. However, no one particular town was focussed on, and again, the vast majority of skeletal data came from large cemetery assemblages. Furthermore, the focus of the study was health in Britain: although diet and population structure were touched on briefly, these themes were not considered in any depth. Subsequent health reviews (e.g. Roberts, 2009) have again analysed large quantities of osteological data from numerous archaeological sites, but they focus on broad changes in the patterns of health over time and are not restricted to one particular town or settlement.

In other cases, data from more than one cemetery site may be compiled and made available for use by others, but is not necessarily analysed and/or fully interpreted in regards to the whole town. The Museum of London Centre for Human Bioarchaeology website, for example, has the Wellcome Osteological Research Database, which provides osteological data and cemetery summaries comprising data for several thousand burials from multiple time periods and all areas of London. However, the purpose of this database is to allow researchers from all over the world to access osteological data from London and assess its research potential in light of their own work. Furthermore, the database is mostly restricted to data from the larger skeletal assemblages from London. The sheer amount of data available for the city of London means that an overall assessment of the material (even from just one time period) would require an enormous amount of time and work.

As demonstrated above, no previous study entirely adopts the approach utilised in this doctoral project, as no body of work employs the same method of data collection or type of data, or considers all of the same themes. Although there has been a notable shift from case studies to population studies in published literature in recent years, there has been little attempt to incorporate piecemeal finds (particularly those discovered on developer funded archaeological projects) into a wider population study. This study is the first of its kind to take this important step and incorporate all available osteological data from one time period at one settlement, no matter the size or source.

Demographic analysis regards a population as one object that can be studied quantatively, in order to examine and elucidate differences in its structure, size and dynamics (Chamberlain, 2006: 1). The results gained from demographic modelling and data (osteological or otherwise) can be used to strengthen archaeological theories concerning population structure, dynamics and behaviour, and can help with the interpretation of archaeological assemblages and sites (Chamberlain, 2006: 4). Demographic analysis is therefore a very important tool in osteoarchaeology. While results produced using demographic analyses are largely theoretical, when combined with other strands of evidence (e.g. archaeological, ethnographic, epigraphic) and rigorous statistical testing, they can provide the potential to make good, educated estimations and interpretations about the aforementioned attributes of the population in question.

A good example of demographic analysis being used in conjunction with complimentary strands of evidence is the study of a human skeletal assemblage from Rupert’s Valley, on the island of St Helena in the South Atlantic. Demographic analysis of an assemblage of 325 human skeletons from mid-nineteenth-century graveyards in Rupert’s Valley was conducted as part of routine osteological analysis (Pearson *et al*., 2011: xviii and 60). The initial hypothesis stated that individuals from this cemetery were likely to have arrived at St Helena after being taken from slave ships captured by the British Royal Navy, during the period when Britain was actively involved in attempting to abolish the transatlantic slave trade (Pearson *et al*., 2011: xviii). Osteological assessment of biological sex (in adult individuals) and age at death found very high proportions of children aged less than 18 years in the cemetery assemblage, as well as significantly higher than expected proportions of adult males (84% of sexed adults were found to be male) (Pearson *et al*., 2011: 62). Although demographic data from historic sources such as shipping and plantation records show that the age and sex preferences of slaves taken from Africa fluctuates temporally (and also according to factors such as the country of origin/destination), the overall general trend shows that adult females were preferred up until the seventeenth-century, when numbers of adult female slaves drop and the number of child slaves aged less than 15 years rises (Eltis, 1986; Geggus, 1989; Eltis and Engerman, 1992; 1993; Pearson *et al*., 2011: 62). The demographic composition of the human skeletal assemblage from Rupert's Valley is therefore consistent with the expected structure of post-seventeenth-century slave populations. The combined demographic, osteological, historical and archaeological evidence all suggests that the human skeletal remains from this site represent individuals that were liberated from the African slave trade by the British Navy during the mid-nineteenth-century. This study clearly demonstrates the way in which demographic data, used in conjunction with other appropriate, complimentary lines of evidence, can aid in the interpretation of a human skeletal assemblage. Similarly, the present study will combine demographic data from Roman York with archaeological, epigraphic and historical evidence (where possible), in order to determine and interpret the structure of this population.

The study of dietary composition and change in the past is important as it allows us to investigate social and cultural development within populations. Diet (for both the individual and wider population group), is not simply a reflection of food availability and consumption in order to survive. The type of food a person (or group) consumes is likely to be affected by multiple factors such as personal preference, age, sex, religion, and social and economic status. The study of di*et al*so has wider implications, for example if foods are being distributed over large geographical distances, we may discover evidence of trade, transport, culture contact/diffusion, and economic development.

Dietary composition and reconstruction is commonly investigated osteologically via stable isotope analysis. This typically involves the measurement of carbon and nitrogen isotopic ratios (by isotopic ratio mass spectrometry) present in bone and tooth enamel. Isotopic ratios are indicative of dietary composition, as isotopic ratios differ between food sources (particularly between terrestrial and marine foods: Tykot, 2004: 433). When food is consumed, the isotopes are incorporated into the bodily tissues, such as tooth enamel and bone. The constant resorption and replenishment of bone collagen and apatite means that the isotopic ratios present in archaeological bone reflect average dietary composition in the last few years of life (Tykot, 2004: 434). Isotope ratios taken from tooth enamel reflect dietary composition during the period of tooth crown formation, as teeth are not dynamic tissues and so do not change composition or remodel over time (Hillson, 1990: 136-7; Tykot, 2004: 434). Stable isotope analysis have become increasing popular in recent years, particularly in regards to investigation and reconstruction of past human diets (e.g. Richards *et al*., 1998; 2006; Le Huray and Schutkowski, 2005; Müldner and Richards, 2005; 2007; Finucane *et al*., 2006; Jay and Richards, 2006). However, the technique does have its limitations. The results gained from stable isotope analysis are typically very broad, and rather than being reflective of overall diet, tend to reflect the isotopic signature of the main sources of dietary protein (Ambrose and Norr, 1993; Müldner and Richards, 2005: 40). These are only distinguishable in broad categories, e.g. carnivore, herbivore or plant protein originating from a terrestrial or marine environment (Müldner and Richards, 2005: 40). A number of proteins cannot be distinguished from each other at all, e.g. meat and dairy products from the same animal (O’Connell and Hedges, 1999; Müldner and Richards, 2005: 40). For these reasons, dietary study using stable isotope is best utilised as a complimentary source of evidence, to be tied in with evidence from other sources e.g. the epigraphic record, zooarchaeological and archaeobotanical evidence.

Macroscopic identification of dental pathological conditions is a routine part of osteological assessment. The presence, location, and severity of any dental pathological conditions is likely to be influenced by a multitude of factors including diet, oral hygiene, age, levels of fluid consumption, and overall health.

Therefore, contributory factors other than diet are likely to influence dental pathological rates to some extent. However, numerous clinical studies have demonstrated that the development of certain dental conditions is broadly correlated with specific dietary intake, i.e. consumption of particular types of food (e.g. Hillson, 1979: 150; Nishida *et al.*, 2000: 330; Moynihan, 2002: 565; Chapple *et al.*, 2007; Yu *et al.*, 2007; Zero *et al.*, 2008; Milgrom and Ly, 2012: 146; Moynihan, 2012: 100). If the results of these studies are correct, it should be possible to identify broad dietary trends within an archaeological population by examining dental pathological prevalence. Of course, as with stable isotope results, the most appropriate use of macroscopically observed pathological data requires comparison of results to other sources of evidence (e.g. zooarchaeological or archaeobotanical evidence for foodstuffs available for consumption by the population in question). However, the macroscopic method has an advantage over use of stable isotope analysis, as it does not require destructive sampling, the potentially costly use of a mass spectrometer, and can be performed easily in any standard laboratory setting.

Furthermore, in the case of the Roman population of York, isotopic study of diet has already been conducted on a substantial sample of skeletal material (as discussed in Chapter 2: Müldner, 2005; Müldner and Richards, 2007). Therefore, the present study will collect macroscopic dental pathological prevalence data, and compare the results of isotopic and other appropriate evidence that may be indicative of dietary composition in this population.

A good example of a dietary study using macroscopic observation of dental pathological conditions is the Belcastro *et al*. (2007) study of dietary continuity in central Italy during the Roman Imperial-early Middle Ages transition (approximately the fourth- to eighth-centuries A. D.). This study examines the prevalence of dental-alveolar pathologies and alterations (such as dental calculus, caries, ante-mortem tooth loss, abscesses and enamel hypoplasia) in skeletal samples from the aforementioned time periods, in order to try and determine whether there was any temporal dietary change (Belcastro *et al*., 2007: 381). For example, similar prevalence of dental caries and ante-mortem tooth loss in both skeletal samples was used to infer continued consumption of high levels of carbohydrates across both time periods (Belcastro *et al*., 2007: 392). Dental findings were also correlated with evidence from historic sources (e.g. contemporary literature) for diet during the two time periods in order to observe whether historically documented dietary components matched the likely dietary patterns suggested by the dental evidence (Belcastro *et al*., 2007: 389-91). The results of the study imply that there was continuation of the same dietary habits across the time period in question, which in turn suggests continuation in the methods of territorial resource exploitation (Belcastro *et al*., 2007: 392).

Health (or lack thereof) is a fundamental component of human life experience. Every person, at some point during life, will experience disease in some form. It is therefore necessary to study patterns of health if we are to try and fully comprehend life experience in past populations. Human remains are the most direct source of evidence that can be used to study past health. In archaeological investigations, skeletal remains are the most commonly surviving part of the human body. This study takes a biocultural approach to ascertaining health status. This approach links biological evidence for disease (obtained from the osteological data) with archaeological, epigraphic, and literary evidence pertaining to the population of Roman York and its associated culture, in order to ascertain how the observed health patterns may have been caused.

The best example of a published biocultural study of human health in the past is Roberts and Cox's (2003) study, *Health and Disease in Britain*. This study uses osteological evidence from (largely published) archaeological populations dating from the late Upper Palaeolithic to the present day, and located all over Britain, to establish crude and true disease prevalence rates (Roberts and Cox, 2003). This information is then combined with evidence from multiple other sources to predict health status in each time period, assess how health changed over time, and offer interpretations to explain why the observed pattern of health may have occurred (Roberts and Cox, 2003). While very ambitious and extremely broad in scope, this study was the first major attempt to reconstruct health status for an entire country, in all osteologically observable time periods. This study has also become the standard source of data for health in archaeological populations. Since its initial publication in 2003, no subsequent health study has managed to replicate the scope of this project or provide a review of the same quantity of osteological material. The present project will use the same methodological principles as the Roberts and Cox (2003) study in order to examine health status in the population of Roman York (see Chapter 3).

1.4. Summary

The Roman population of York is an excellent case study to use for the present project. Roman urban populations in the north of England are seldom studied, principally because of the lack of available osteological material. York is one of the few Roman sites in the north of England that has substantial osteological assemblages available, with the added advantage that the combined osteological assemblage covers the entire period of Roman occupation, is derived from burial sites located on all sides of the town, and therefore is likely to constitute a good cross section of the population. The present project makes a very important contribution to our sum of knowledge about Roman York, as it is the first study to combine all these data, therefore significantly increasing the collective amount of osteological data available for Roman York. The project also produced new evidence, which, when combined with existing evidence from multiple sources, creates a very comprehensive picture of the population. Furthermore, this study offers original social interpretation and analysis of the combined osteological and archaeological evidence.

The main aims of this study are broad ranging, and will serve to tie together well-known archaeological and osteological information with data that have previously received little or no attention. Factors such as demographic composition, diet and health status of a population are important components of population dynamics and their examination is crucial in understanding the mechanisms that influence development and change past populations. Focus on these three key themes will allow the comprehensive reconstruction of an important urban population and assessment of its growth and transformation throughout the Roman period of occupation.

The following chapter will contextualise the study by presenting a summary of the history of Roman York from establishment to decline, based on archaeological, osteological, literary and epigraphic evidence. In addition, the chapter will review the major archaeological studies conducted on York during the Roman period, with the main focus on study of the cemetery areas and associated evidence for funerary practices. The third chapter will outline the materials and methodologies employed in this study, including details of the total study area and burial locations of material from Roman York, details of material from other comparative Roman urban osteological assemblages, the demographic models and methods employed in examination of population structure and size, and methods of calculating true and crude dental and non-dental pathological prevalence. The fourth chapter will present the results of data aggregation and statistical analyses, including estimates of population composition in terms of sex ratio and patterns of mortality across all observed age groups, estimations of population size, predicted dietary components based on observed prevalence and patterns of dental pathological conditions, and observed patterns of health at York and in comparison to observed health patterns at all comparative Romano-British urban sites. The fifth chapter discusses interpretation of the results in light of their archaeological context, including explanations for the observed sex ratio and pattern of mortality, discussion of the estimated population size in comparison to previous approximations, discussion of evidence for food types that are likely to have been exploited during the Roman period (consumption of which may, in turn, explain observed prevalence of dental pathological conditions in the York population), and discussion of observed health status in the York population in relation to the most commonly experienced health problems and how this compares to elsewhere in Roman Britain and the rest of the Roman Empire. The final chapter concludes by summarising the present project, returning to the original research questions and providing answers in light of this study’s findings.

Chapter 2: *Eboracum* in Context

This chapter provides an overview of the establishment and development of *Eboracum* (Roman York) from the first century A. D. through to the decline of the settlement in the fifth century. Understanding of the development and history of the town during the Roman period sets the population (both living and deceased) in its historical context; contextualisation of the population is crucial if we are to successfully interpret and fully comprehend the findings of this study. Furthermore, this chapter will summarise the main archaeological studies of *Eboracum*, highlighting, in particular, investigation and examination of the cemetery areas. Certain burial areas, particularly those to the south west of York where burial density is assumed to be highest, have previously been subject to extensive study, while other areas, where burials are more piecemeal, have been deemed to be of limited academic interest. This chapter will also emphasize the importance of examining the town's population as whole, rather than concentrating on the larger cemetery populations. Lastly, this chapter will focus on the archaeological evidence for funerary and burial practices at York during the Roman period, focussing on the extent to which the archaeological evidence suggests burial customs were Romanised, or reflective of pre-conquest indigenous practices.

2.1. *Eboracum* - The Growth and Decline of a Romano-British Town

York is located in the north of England, in the present day county of North Yorkshire (Figure 2.1). It is generally accepted that the legionary fortress at York was founded in 71 A. D. (Home, 1924: 22; RCHME, 1962: xxix; Hartley, 1971: 55; Hartley, 1980: 4; Addyman, 1984: 14; Roskams, 1999: 50; Ottaway, 1999: 137; Ottaway, 2004: 31). This date is largely based on the analysis of a description of a military campaign written by Tacitus in 98 A. D., in his biography of Agricola (Rollason, 1998: 36-7; Ottaway, 2004: 31). This account describes a military campaign whereby Governor Petillius Cerealis advanced his army on the indigenous Brigantes from the direction of York (Rollason, 1998: 37). Tacitus refers to the attack as commencing *statim* ("at once") and this has been interpreted as a reference to the attack taking place as soon as Petillius Cerealis arrived in

Britain in the spring of 71 A. D. (Rollason, 1998: 36). The known association between Petillius Cerealis and the Ninth Legion, combined with evidence demonstrating the presence of the Ninth Legion at *Eboracum*, has led to the supposition that Petillius Cerealis was responsible for the foundation of the original fortress (Home, 1924: 22; RCHME, 1962: xxx; Hartley, 1980: 4; Rollason, 1998: 36-7). Current archaeological evidence is unable to confirm or refute this date, although it has been suggested that a number of pottery fragments excavated at the site of the East Angle tower and at a timber tower on the south west side of the fortress have a typology that is consistent with the establishment of the fortress between A. D. 71-74 (RCHME, 1962: 7; Hartley, 1966: 10-11). However, the exact typology of this pottery is unclear, and it is uncertain whether pottery typology could accurately establish so narrow a date range: this ceramic evidence is therefore best considered as tentative. Despite this, there is also no cause to dispute the early 70’s as a date for the foundation of the fortress.

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Figure 2.1: Roman Britain in 150 A. D. (Nacu, 2008). *Eboracum* (present day York) is marked by a yellow circle.

Although it is likely that construction of the fortress did not commence until approximately 71 A. D., there is archaeological evidence that may indicate a small amount of earlier activity at the site (Ottaway, 2004: 33). Archaeological investigation of a sizeable ditch and two pits at 9 Blake Street are indicative of earlier Roman activity, with the primary ditch fill yielding a coin dating to A. D. 66 and pottery thought to date approximately to the reign of the Emperor Nero (A. D. 54-68; Ottaway, 1996: 308-10; Hall, 1997: 377; Ottaway, 2004: 33). The accuracy of this pottery dating is questionable, given that ceramic typologies may persist over relatively long periods of time, and that the time period associated with the reign of Nero is rather short. Furthermore, activity is unlikely to relate to a substantial period of occupation and may be associated with preparations immediately prior to fortress construction (Ottaway, 1996: 308-10; Hall, 1997: 377; Ottaway, 2004: 33). Whatever the case, there is no evidence to suggest the presence of a permanent settlement at this location prior to the building of the fortress (Ottaway, 1999: 138).

The fortress, whilst designed to discourage attacks, was primarily constructed to provide accommodation for the occupying soldiers, to store equipment belonging to the army, and act as a base from which the army could go out and fight in the field (Ottaway, 2004: 29). As well as building the fortress, it is likely that the army took possession of an area of land adjacent to the fortress known as the *territorium* (RCHME, 1962: xxxiv-v; Addyman, 1984: 14; Ottaway, 2004: 53). There is little evidence pertaining to the exact size and location of the *Eboracum territorium*, although it has been suggested that the area covered numerous square miles (RCHME, 1962: xxxv; Ottaway, 2004: 53). The land taken as *territorium* is likely to have covered a diverse range of terrain including woodland, pasture and arable land, with natural resources such as timber and stone being exploited in order to build and maintain the fortress (RCHME, 1962: xxxv; Addyman, 1984: 14; Ottaway, 2004: 53). Furthermore, an area of *territorium* immediately next to the fortress is likely to have housed other staff and the families of the occupying soldiers, as well as being the location of store rooms and workshops necessary for the everyday running and maintenance of the site (Ottaway, 2004: 53). Veteran soldiers are also likely to have made up a significant proportion of this population (Brinklow, 1984: 22).

It is this initial settlement of people immediately outside the fortress that is likely to have initiated the development of the *canabae* (a civilian settlement housing military dependants and civilian contractors working for the military; Ottaway, 2004: 53; 87). Substantial growth of this area of *Eboracum* appears to have started in the second century, and was concentrated immediately around the south and northwest sides of the fortress and the associated main roads (Ottaway, 2004: 88). Although the evidence is limited, especially for the earlier period of growth, the *canabae* is likely to have been made up of a range of public and domestic buildings, interspersed with shops and industrial activity (Brinklow, 1984: 22). The presence of the fortress and associated people would have gradually attracted tradesmen and other persons, which over time would have led to the expansion and formalisation of the settlement (Home, 1924: 150; RCHME, 1962: xxxiv-v; Salway, 1981: 582). The word *canabae* translates as “the booths”, an apparent reference to the many booths and stalls of shop vendors and tradesmen present at the site (RCHME, 1962: xxxiv).

Evidence from archaeological find spots suggests that the new inhabitants of the *canabae* were able to supply the various needs of the fortress and associated population, with the garrison commander having overall control (Brinklow, 1984: 22). For example, ceramic products including tiles have been found at a number of sites, including in the Peasholme Green area of modern day York where tiles were found bearing the stamp of the Ninth Legion (Figure 2.2; RCHME, 1962: 114; Swan, 1992: 1; Ottaway, 1999: 140; Garside-Neville, 2004; McIntyre, 2011). The stamp of the Ninth Legion indicates that manufacture was no later than the early second century, when the Ninth are thought to have left *Eboracum* (Salway, 1981: 174-5; Rollason, 1998: 38). Although at least some is likely to represent secondary deposition, the sheer quantity of material suggests it is unlikely to be far from the original site of manufacture (Brinklow, 1984: 25). Ottaway (2004: 88) has suggested that the tile and pottery kilns are likely to have been situated slightly away from the settlement, probably on the east side of the fortress. Further archaeological evidence for early structures in the *canabae* has included post holes indicative of late first- to early second-century timber structures at High Ousegate, Spurriergate, Gillygate and St Mary’s Abbey (Ottaway, 2004: 87). Substantial archaeological evidence for grain warehouses of this date have also been found on Coney Street (York Archaeological Trust, 1975a; Hall and Kenward, 1976; Ottaway, 1999: 140).

Figure 2.2: Roof tile bearing the stamp of the Ninth Legion, found during excavations at York Railway Station. Currently on display at the Yorkshire Museum (McIntyre, 2011)

As the *canabae* expanded and diversified on the north-east side of the River Ouse, so too began the development of a settlement on the south-west bank. Ottaway (2004: 90) observes that this area “for the sake of convenience ... is usually referred to as the *colonia*”. The title of *colonia*, however, was not granted until at least the third century (Millett, 1999: 193; see further discussion below). Although the specifics of early development of this area are largely unknown, the earliest likely evidence of Roman settlement on the south-west side of the Ouse relates to traces of timber structures located at the present site of the railway station, and dating to the late first to early second century (Ottaway, 2004: 91-2). Further structures and features of a similar date have been observed at Blossom Street (buildings refuse and ditched enclosures) and Fetter Lane, where a bath house was found with floor tiles bearing the stamp of the Ninth Legion (RCHME, 1962: 52; York Archaeological Trust, 1994b; Burnham *et al.*, 1995: 345; Ottaway, 2004: 91-3). The archaeological evidence, therefore, suggests that development of what would become the *colonia* is likely to have initially been located around the main approach road into *Eboracum*.

As well as growth of the *canabae* and what would become the *colonia*, archaeological evidence shows that the fortress also underwent multiple phases of remodelling and rebuilding, including rebuilding of the earlier wooden fortress in stone (Ottaway, 1999: 141). Although there appear to have been many phases of renovation throughout the entire period, evidence suggests that the phases belonging to the early-mid second century may be related to the arrival of the Sixth Legion. The last known written reference to the Ninth Legion in *Eboracum* dates to A. D. 107-8 (Birley, 1971: 72). This inscription comes from a commemorative tablet, possibly from a gateway, erected by the Ninth Legion in A. D. 107-8 (Birley, 1971: 72; Rollason, 1998: 38; 84-5). After leaving *Eboracum*, the Ninth Legion appears to have spent some time in Carlisle (possibly in the early 120's) before being transferred to Nijmegen in the Netherlands (Birley, 1971: 74; Wright, 1978; Ottaway, 1999: 141; Keppie, 2000a: 175; Ottaway, 2004: 57). Although these dates are only approximate, all evidence suggests that the Ninth Legion had vacated the fortress at *Eboracum* by the time the Sixth Legion arrived c. A. D. 120 (Hartley, 1971: 60; Ottaway, 2004: 57).

The arrival of the Sixth Legion initially saw lower levels of occupation of the fortress, possibly because although they were based at *Eboracum*, part of the legion was sent to work on Hadrian's Wall and the Antonine Wall (Ottaway, 1999: 141). Despite this, archaeological evidence shows that extensive refurbishment of the fortress continued throughout the period of occupation by the Sixth Legion (Birley, 1971: 91; Hall, 1997; Ottaway, 2004: 57-81). Industrial practices in the *canabae* also continued, again either overseen or directly carried out by the Legion itself. Roof tiles and pottery bearing the stamp of the Sixth Legion have been found at sites such as Peasholme Green and Museum Gardens, including a new range of cooking vessel types indicative of local manufacture by individuals of North African origin (RCHME, 1962: 114; Birley, 1971: 90; Swan, 1992). Evidence of glass manufacture and melting has also been found at Coppergate, as well as evidence of ferrous and non-ferrous metalworking again in the area encompassed by the *canabae* (Cool *et al.*, 1999).

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Figure 2.3: The Multangular Tower, Yorkshire Museum Gardens (Pemmot, 2006)

After the initial period of growth, refurbishment and change, by far the most substantial development in the size and status of *Eboracum* seems to have taken place from the late second/early third century. A comprehensive review of all refurbishment and changes to the fortress are beyond the scope of this chapter. However, known modifications include continued replacement of timber features with stonework, construction of several stone towers (including the structure now visible in Museum Gardens as the Multangular Tower: Figure 2.3), realignment of the fortress ditch system and construction of a new rampart (Rollason, 1998: 39; Ottaway, 2004: 67-75).

Similarly, evidence indicates considerable expansion and development of settlement areas on both sides of the river. Expansion seems to have occurred episodically, as opposed to gradually and uniformly as part of a long term grand scheme (Ottaway, 2004: 94). Previously developed areas were re-organised and street layout changed: for example the later phase of a grain store on Coney Street was replaced by a gravel street edged with a stone drain (York Archaeological Trust, 1975a; Ottaway, 2004: 88). Construction of a number of buildings, including monumental structures was undertaken, including another bath house and other substantial buildings at High Ousegate/Spurriergate, a public building of unknown function and a monumental wall structure at St Mary's Abbey, a temple dedicated to Hercules at Nessgate, and a possible monumental "guildhall" on Wellington Row (RCHME, 1962: 59-61; York Archaeological Trust, 1987; Ottaway, 2004: 88-9). Public works such as renovation of the drainage system were also carried out (Ottaway, 2004: 94).

Archaeological evidence for the development, improvement, and refurbishment of the town in the late second and early third century is consistent with the suggestion that *Eboracum* was a town of growing importance, and is similarly indicative that the status of *colonia* is likely to have been granted around this time. The status of *colonia* was usually used in reference to towns of a specific status: urban colonies with dependent territory located within the Roman Empire and deliberately modelled on Rome (Hurst, 1999: 9, Mattingly, 2007: 260-1). Many *coloniae* were established in various parts of the Empire as settlements for retired veteran soldiers; this is certainly thought to be the case at Colchester, Gloucester and Lincoln (Mattingly, 2007: 260). York is a slightly different case, as this status appears to have been granted well after the town had been established.

The exact date that *colonia* status was granted to *Eboracum* is unknown, though various lines of evidence have been used to suggest it happened sometime in the early third century (Hurst, 1999: 9; Millett, 1999: 191-6; Ottaway, 1999: 146; Mattingly, 2007: 192-3). The earliest known reference to the *colonia* status of *Eboracum* comes from an inscription found on a stone altar in Bordeaux, dating to A. D. 237 (RCHME, 1962: xxxvi; Rollason, 1998: 42). A reference to *Eboracum* made by Sextus Aurelius Victor in his *Book on the Roman Emperors* (written in approximately 360 A. D.), describing the death of Emperor Septimius Severus in A. D. 211, refers to the town as a *municipium* ("chartered town"), which may suggest that *colonia* status was granted at some point between A. D. 211 and A. D. 237 (Salway, 1981: 583; Rollason, 1998: 89; Mattingly, 2007: 261). However, the accuracy of this reference has been disputed, as Sextus Aurelius Victor's writing post-dates the event he describes by over a century and a half (Rollason, 1998: 89). This has led to a certain amount of debate over whether *Eboracum* was promoted to *colonia* status during or just after the reign of Septimius Severus, who resided there from A. D. 208-11. While it is agreed that the granting of *colonia* status was honorary in view of the town’s elevated prestige, it has been argued that the Emperor’s residency was the reason for promotion (RCHME, 1962: 49; Salway, 1981: 575; Millett, 1990: 91; Mattingly, 2007: 261). However, if Sextus Aurelius Victor’s *municipium* reference is accurate, *Eboracum* is more likely to have changed status at the time it was made the capital of *Britannia Inferior* by Emperor Caracalla in approximately A. D. 211-13 (Ottaway, 1999: 146; Ottaway, 2004: 83; Mattingly, 2007: 126).

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Figure 2.4: Emperor Septimus Severus.
(Trustees of the British Museum, 2013)

Emperor Septimius Severus (Figure 2.4) arrived in Britain in A. D. 208, using *Eboracum* as his headquarters and campaign base in the fight against the Caledonian tribes (RCHME, 1962: xxxvi; Hartley, 1971: 65; Rollason, 1998: 41; Ottaway, 1999: 146; Ottaway, 2004: 79). It has been suggested that the Emperor and his troops would remain out on campaign for the majority of the year, returning to *Eboracum* every winter (Mattingly, 2007: 123). There is little in the way of archaeological evidence pertaining to this time, although construction of some of the more monumental structures have been attributed to the Severan period of occupation, such as the multangular towers at the south and west corners of the fortress (Ottaway, 1999: 146). By the time Severus arrived at *Eboracum* he was already 60 years old and in ill health (Ottaway, 2004: 79). After three years of campaigning against the Caledonian tribes, Severus died in February A. D. 211 (Birley, 1979: 29; Ottaway, 2004: 80, Mattingly, 2007: 124). He was cremated, probably just outside *Eboracum*, and his ashes returned to Rome (Home, 1924: 69; Ottaway, 2004: 80).

The family of Severus are thought to have left Britain relatively soon after his death (Mattingly, 2007: 124). By A. D. 213 his son, the now Emperor Caracalla, had split Britain in two: *Britannia Superior,* whose capital was *Londinium,* and *Britannia Inferior,* whose capital was *Eboracum* (Salway, 1981: 231; Higham, 1986: 210; Rollason, 1998: 41; Millett, 1990: 131; Mattingly, 2007: 126). *Eboracum* would, therefore, also have acted as the seat for the governor of *Britannia Inferior* (Mattingly, 2007: 126). This theory is supported by an inscription found in Vieux in northern France, which refers to Tiberius Claudius Paulinus as "*legato Augusti pro praetore in Britannia ad legionem sextam*". This indicates that he was both legate of the Sixth Legion and governor of *Britannia Inferior*, the combination of positions further implying that it is likely that Paulinus was based in *Eboracum* (Hirschfeld and Zangemeister, 1899; Rollason, 1998: 42).

The exact history of events in *Eboracum* is somewhat hazy for the mid to late third century, with a notable lack of dateable inscriptions and documentary evidence. There is archaeological evidence of construction and/or enlargement of some of the town houses to the south west of the River Ouse, probably dating to the late third or early fourth century (Ottaway, 1999: 147). During approximately the same period there is also evidence of the construction of a large house at Clementhorpe and extension and refurbishment of a building at St Mary Bishophill Senior (York Archaeological Trust, 1973; 1977a; Ottaway, 1999: 147). Furthermore, a number of mosaics have also been found, the most famous example being the Four Seasons mosaic from Toft Green (Figure 2.5), with other examples found at sites such as Aldwark (Figure 2.6), St Mary Castlegate, and in other parts of the northwest area of the colonia (RCHME, 1962: 59; York Archaeological Trust, 1976; Ottaway, 1999: 146; York Museums Trust, 2012). This evidence may suggest that *Eboracum* continued to be used as a prestigious governmental centre into the fourth century (Ottaway, 1999: 146).

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Figure 2.5: The Four Seasons mosaic from Toft Green (York Museums Trust, 2012)

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Figure 2.6: Fragment of mosaic from Aldwark (York Museums Trust, 2012)

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Figure 2.7: Statue of the Emperor Constantine, located outside York Minster, erected in 1998 (York Civic Trust, 2012)

A. D. 305 saw the arrival of Emperor Constantinius Chlorus and his son Constantine in *Eboracum*, as part of a campaign against the *Picti*, or Pictish tribes of Scotland (Mattingly, 2007: 233-4). Constantinius died in *Eboracum* the next year and Constantine was immediately proclaimed Emperor (Figure 2.7; De La Bédoyère, 2003: 177; Rollason, 1998; 44; Mattingly, 2007: 234; Casey, 2009: 82). Although various phases of rebuilding and remodelling of the fortress have previously been attributed by the Royal Commission to the time when Constantine was in *Eboracum*, these assumptions have since been found to be misguided (RCHME, 1962; Phillips and Heywood, 1995; Ottaway, 2004: 63; Hartley *et al.*, 2006). In fact, Constantine did not stay in *Eboracum* for very long after being proclaimed Emperor, leaving Britain for Trier, which he made his base for future campaigns (Hartley *et al.*, 2006: 12).

By A. D. 312, Britain had been divided a second time: *Britannia Superior* was divided into *Britannia Prima* and *Maxima Caesariensis* and *Britannia Inferior* was divided into *Britannia Secunda* and *Flavia Caesariensis* (De la Bédoyère, 2003: 90). The exact boundaries of these four provinces are currently unknown, although the approximate locations and extent of each region is shown in Figure 2.8. The names of the provinces derive from a contemporary list of all the Roman Provinces known as the *Verona List*, dating to A. D. 312-14 (Barnes, 1975; Rollason, 1998: 44; Mattingly, 2007: 334). *Eboracum* is thought to have been made the capital of *Britannia Secunda,* evidenced by the appointment of a bishop to the town by A. D. 314 (Rollason, 1998: 44; Ottaway, 2004: 132; Mattingly, 2007: 334-5). Christianity became the official religion of the Roman Empire in A. D. 312 after the conversion of Constantine (Salway, 2009: 227; Rogers, 2011: 33). Documents relating to the Council of Arles, which took place in A. D. 314, record the attendance of bishop "*Eborius Episcopus de civitate Eboracensi*" (Eborius Episcopus of the city of York; Home, 1924: 95; Birley, 1979: 151; Rollason, 1998: 44; Mattingly, 2007: 348). Retaining its position as a capital city, albeit of a slightly smaller region, undoubtedly meant that *Eboracum* was still of significant status during the fourth century.

The latter part of the Roman occupation of *Eboracum* is characterised by change and decline. It is during this time that troops were gradually being recalled from Britain. Troops were withdrawn from various regions of the Empire by a number of individuals wanting to challenge for the right to rule as Emperor, starting with Roman General Magnus Maximus in A. D. 383, who was the first to remove troops from *Eboracum* (Ottaway, 2004: 144). The meagre archaeological evidence pertaining to the mid to late fourth century still indicates occupation of the town, but also shows significant change in the somewhat contradictory forms of both refurbishment and destruction. This lack of evidence is at least partially the result of truncation of Roman features by later features and deposits (Ottaway, 2004: 144).

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Figure 2.8: Political divisions in fourth century Roman Britain (Nash Ford, 2003)

A few examples of refurbishment of existing structures have been observed archaeologically. For example, several older statues and altars appear to have been removed from the basilica of the *principia* (headquarters) of the fortress during the mid to late fourth century; newer pedestal bases were also found archaeologically, presumably for the insertion of new statues (Ottaway, 2004: 140). Unfortunately, this dating is stratigraphic in character, and therefore only tentative. Another room had been built to the north-west end of the basilica, with decorative painted plaster on the wall; this room has been interpreted as possible accommodation for a senior officer (Ottaway, 2004: 141). Furthermore, there is also evidence for re-cutting of the southwest fortress ditch, which probably occurred in the mid to late fourth century (Ottaway, 2004: 141).

Other buildings, however, have evidence of destruction and significant changes in their character and function. Many of the principal fortress buildings excavated at 9 Blake Street appear to have been demolished by the late fourth century, with many of the flagstones removed from the floor (Ramm, 1971: 185; York Archaeological Trust, 1975b; Ottaway, 2004: 145-5; Rogers, 2011: 158). The remaining surfaces were then overlain by refuse deposits containing large quantities of animal bone and broken pottery (Ottaway, 2004: 146; Rogers, 2011: 158). In the kitchen, new floor surfaces had been laid comprising crushed tile and mortar before the accumulation of refuse began, strongly suggesting that the function of these rooms had changed from their original purpose (preparation of food) to a dumping area where refuse was casually left (Ottaway, 2004: 145-6; Rogers, 2011: 158). Evidence of metal-working workshops in the form of hearths has also been found in a building range to the rear of the fortress (Ottaway, 2004: 146). Phillips and Heywood (1995: 64) have used all this evidence to suggest that the army stripped down the fortress complex prior to leaving.

Increased rubbish dumping is also seen in the civilian settlement from the late fourth century. The formation of deposits very similar to “dark earth” at several sites (including the General Accident site at Tanner Row, Wellington Row, 5 Rougier Street and 37-38 Bishophill Senior) suggests that by this time, previously inhabited areas of the town were starting to be used for refuse disposal (York Archaeological Trust, 1973; 1981; 1984; 1987; Ottaway, 1999: 147; Ottaway, 2004: 146 and 149). “Dark earth” is a deposit (often silty or loamy) that is frequently found on Romano-British urban sites, overlaying late Roman contexts but stratigraphically earlier than Anglo-Saxon contexts (Yule, 1990; Dark, 1994: 15; Ottaway, 2004: 146). Although the exact composition varies between deposits, this type of material is usually largely organic (often associated with domestic or industrial refuse) and has in some cases been associated with site abandonment (Yule, 1990: 626; Dark, 1994: 15; Ottaway, 2004: 146 and 148). The presence of dark earth and dumping of other domestic/industrial waste is something that may indicate a general loss in civic pride, with the populace preferring to throw rubbish into empty buildings rather than conforming to previous method of regulated, municipal refuse disposal (Faulkner, 2001: 124).

Evidence for continued occupation of *Eboracum* during the fifth and sixth centuries is scant, which may reflect depopulation of the town (Ottaway, 1999: 149; Ottaway, 2004: 149). However, it is unlikely that the settlement was completely abandoned. Mattingly (2007: 533) refers to the archaeological evidence for continued use of the *principia* of the fortress during this period: the presence of metalworking hearths indicates the area eventually because used as a workshop rather than a military headquarters (Ottaway, 2004: 146). Anglian cremation cemeteries dating to approximately the late fifth/early sixth centuries have been found in the Heworth area and at The Mount (Stead, 1958; Myres, 1977; Ottaway, 1999: 149). These areas, therefore, appear to have continued association with burial and funerary procedures during this period. However, it is uncertain where the population utilising this burial area was based. Despite being indicative of retained knowledge of the function of these areas, the fifth- and sixth-century burials cannot be used as direct evidence of continued settlement at York at this time.

Archaeological evidence, however, has been found for the re-use of Roman structures in Anglian York. Post holes indicative of a timber structure of Anglian date (a more specific date has not been determined) were found cut into two walls of the bath house at 1-9 Micklegate (York Archaeological Trust, 1989a; Ottaway, 2004: 151). The walls of the bath house are likely to have been demolished in the late fourth century; later cutting of post holes indicates that the location of the building was still known, although the precise date of this later timber structure is unknown (York Archaeological Trust, 1989a; Ottaway, 2004: 151). Again, this does not provide evidence of continued occupation by a substantial population, but it does suggest retained knowledge of the settlement.

There is also epigraphic evidence for York having retained (or at least regained) its status by the seventh century. Bede's *Ecclesiastical History* states that King Edwin of Northumbria was baptised in York in 627; the town must, therefore, have kept a significant level of ecclesiastical status by the early seventh century in order for this to have taken place (Barrow, 2011: 704). Despite the lack of physical evidence for continuity of settlement between the Roman and Anglian periods, this reference combined with archaeological evidence from the seventh century onwards suggests that it is inappropriate to propose total abandonment of York in the sub-Roman period. The continued excavation of archaeological sites in York may yield more substantial evidence pertaining to this period.

2.2. Archaeological Study of *Eboracum*

The history of *Eboracum* outlined above could not have been constructed without archaeological evidence. A number of archaeological studies of Roman York, both published and unpublished, have been conducted since the seventeenth century. Although a full review of all studies related to *Eboracum* is beyond the scope of this chapter, this section aims to summarise the main archaeological studies in chronological order. Summary of the main archaeological studies conducted in York up until the present day allows us to see how interpretations of archaeological evidence and understanding of the Roman period in this city has changed over time.

The first known reference to Roman discoveries relating to York can be attributed to William Camden, who noted finds such as a stone coffin belonging to Verecundius Diogenes (discovered in 1579) in his 1587 publication *Britannia* (Ottaway, 2004: 15). Further early studies of York during the Roman period were undertaken (albeit on a somewhat *ad hoc* basis) by various antiquarians during the seventeenth and eighteenth centuries. Noteworthy individuals include Martin

Lister, who is credited as being the first man to identify the Multangular Tower as Roman, Ralph Thoresby, who collected a significant number of Roman antiquities from excavations in areas such as Bootham, and John Horsley, whose account of Roman York was largely used as the basis for Francis Drake's publication *Eboracum* in 1736 (RCHME, 1962: xxxix). *Eboracum* is the first known comprehensive review of Roman antiquities from the city, and draws on the work of numerous individuals (Drake, 1736; RCHME, 1962: xl). Many other papers on Roman York, its antiquities and the results of investigative excavations were published during this time in newspapers and journals such as the *Philosophical Transactions of the Royal Society*, and *Archaeologia* (RCHME, 1962: xxxix-xli).

A number of works on Roman York were published in the nineteenth century. William Hargrove's *History of York* included much of the material from Drake's *Eboracum*, as well as a wealth of new material (Hargrove, 1818; RCHME, 1962: xl). Charles Wellbeloved, one of the founders of the Yorkshire Philosophical Society, published *Eburacum, or, York under the Romans* in 1842; this publication has been described by the RCHME (1962: xl) as "the first systematic account of Roman York". Importantly, this publication included detailed first hand descriptions and illustrations of archaeological findings, including the fortress defences and structures excavated at the old Railway Station (Wellbeloved, 1842; RCHME, 1962: xl). As in the seventeenth and eighteenth centuries, copious discoveries were reported in newspapers and popular journals such as the *Gentleman's Magazine*.

The most extensive studies of *Eboracum* have taken place since the beginning of the twentieth century. Yet another review of the history of *Eboracum* was published in 1924, by Gordon Home. His *Roman York* incorporates both archaeological and epigraphic evidence to create a chronological history of the town (Home, 1924). The town of *Eboracum* is discussed with consideration of its position and status within the wider Roman Empire, and the volume also considers day to day life for its inhabitants. The first systematic large scale archaeological excavations took place under the direction of Stuart Miller, sponsored by the Yorkshire Archaeological Society's Roman Archaeology Committee (Ottaway, 2004: 17; Ottaway, pers. comm.). Excavations between

1925 and 1928 uncovered substantial sections of fortress structure, some of which are still visible today (RCHME, 1962: xli; Ottaway, 2004: 17). The results of these excavations were published in the *Journal of Roman Studies*, the entire archive being stored at the Yorkshire Museum (Miller, 1925; 1928; RCHME, 1962: xli).

The Royal Commission report on the monuments of Roman York was by far the most exhaustive study of *Eboracum* when it was published in 1962. The study documented the known history of the Roman town, before providing an inventory of all known approach roads, military sites, civilian sites, burials, inscriptions and other finds discovered since the seventeenth century (RCHME, 1962). Not only were photographs of excavated sites and artefacts included, but also maps of *Eboracum* and reconstruction illustrations, bibliographic references to all sites and artefacts, and crucially, the current location of artefacts and archives where known (RCHME, 1962). Despite its age and a few (now) somewhat dated interpretations, the Royal Commission report is still an invaluable tool in the study of *Eboracum*. Records for many of the early archaeological sites and findspots can prove difficult to access, and the information may have been lost altogether had documentation not been made in this volume. References are also given to both popular and more obscure journals and publications, where information about a site or an artefact can be found. The recent digitising of many eighteenth- and nineteenth-century publications for online viewing (e.g. Francis Drake’s 1736 publication *Eboracum* is now available electronically via the Eighteenth Century Collections Online website) means that access to such publications is quicker and easier than ever before. Furthermore, many of the artefacts listed are still present at the repositories cited by the Royal Commission. This report is, therefore, still a crucial source required for the proper study of York during the Roman period.

Possibly one of the most critical developments in the study of Roman York was the introduction of commercially funded excavation undertaken by archaeological units. The majority of archaeological studies undertaken in York in the last 40 years have been conducted commercially. Probably the first unit to commence this type of work was the York Archaeological Trust (YAT), founded as an independent charity by Richard Hall in 1972 (York Archaeological Trust, 2007).

YAT also conducts developer funded and community archaeology, and has been responsible for countless archaeological investigations of the Roman town, producing innumerable publications and volumes of grey literature as a result. Other commercial units working in and around the York area include On Site Archaeology, MAP Archaeological Consultancy, Fields Archaeology Specialists, Mike Griffiths and Associates, Northern Archaeological Associates and PJO Archaeology. These units have all contributed to the ever growing body of publications and grey literature on the subject, meaning that knowledge and understanding of the history of York (not just in the Roman period) is growing and changing all the time. Recent work by On Site Archaeology, for example, has excavated new areas of the Roman baths complex at the site of the Old Railway Station (Bruce, 2011; Laycock, 2011).

Although the majority of recent research falls under the umbrella of commercial/developer-led excavation, there are a number of studies that cannot be included in this category. Firstly, the most up to date, definitive review of the history and archaeology of *Eboracum* is Patrick Ottaway's *Roman York* (2004). Originally published in 1993, with a later, updated edition published in 2004 (reprinted in 2011), this study draws together evidence from antiquarian studies, the Royal Commission report, and particularly from YAT's substantial body of work. This publication provides the only general overview of Roman York ever published and should be regarded as a core text for anyone studying the town during this period.

Eboracum has also been the focus of a number of studies based on stable isotope evidence, largely stemming from Gundula Müldner's 2005 doctoral study of dietary change in York. Bone samples from 311 individuals dating to the Roman, Anglian, late medieval and post-medieval periods were taken in order to analyse the carbon and nitrogen stable isotope ratios in the bone collagen (Müldner, 2005). Samples dating to the Roman period were taken from the Trentholme Drive and Blossom Street cemetery assemblages (Müldner, 2005: 86; 90). Results showed that as well as the expected terrestrial protein, the population of *Eboracum* was consuming small amounts of marine foods on a regular basis (Müldner, 2005: 192). This suggests a broad dietary change from the preceding

Iron Age, where fish appears not to have been consumed at all (Müldner, 2005: 192-3; Müldner and Richards, 2007).

Further isotopic studies into migration and population diversity in *Eboracum* have also been undertaken. Leach *et al.'s* (2009) study combined isotopic evidence for childhood residency with evidence for ancestry and burial location to try to determine the origin and identity of migrants in the town. Osteological age and sex estimations were made, as well as ancestry assessment via three different methods (multivariate, craniometric and anthroposcopic analysis) on 103 individuals from the Trentholme Drive and Railway cemetery assemblages (Leach *et al.*, 2009). Tooth samples were taken from 43 of these individuals in order to analyse oxygen and strontium stable isotope ratios (Leach *et al.*, 2009: 547). Results of the study showed that a number of individuals had strong affinities with populations from North Africa (Leach *et al.*, 2009). These findings corroborate evidence from Swan's 1992 study of ceramic vessels from *Eboracum*, which suggested that cooking vessels found at the town are North African in form, and indicate the presence of individuals of North African origin or descent within the population.

The same analytical methods utilised in Leach *et al.'s* (2009) study were applied to a single individual from Sycamore Terrace (also known as the "Ivory Bangle Lady") as part of a wider project funded by the Arts and Humanities Research Council, "Diasporas, Migration and Identities" (Leach *et al.*, 2010). The individual in question was discovered in 1901, near Sycamore Terrace in the Bootham area of York (Boynton, 1902: 6; Leach *et al.*, 2010). The skeleton has generally been considered to be that of a wealthy young female, largely based on the striking and unusual array of high-status accompanying grave goods, including elephant ivory bangles, a glass mirror, and several items of jewellery (Figure 2.9; Leach *et al.*, 2010). All these objects have been dated to the second half of the fourth century, suggesting this is when the individual was likely to have been buried (Leach *et al.*, 2010: 1344). Oxygen and strontium isotope and ancestry analysis suggested that this individual could be considered a high-status non-local migrant of mixed ancestry (anthroposcopic assessment of the skull of this individual suggested that the individual exhibited both "black" and "white" traits, and overall, assessment showed closest affinity with African-American populations from the Howell's database: Leach *et al.*, 2010: 141). The results of this study again strongly indicate that the population of *Eboracum* was highly diverse, in terms of both social status and origin of the populace.

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Figure 2.9: The "Ivory Bangle Lady" and her associated grave goods (Imagemakers, 2012)

A multi-isotope study was also recently conducted to investigate the identity of individuals from the Driffield Terrace cemetery assemblage (Müldner *et al.*, 2011). This site is unusual, as almost all the excavated skeletons are male and more than half were decapitated (Müldner *et al.*, 2011). Stable isotopes (strontium, oxygen, nitrogen and carbon) were analysed in order to examine both dietary composition and childhood origin; correlation of both sets of results proved extremely valuable, showing that individuals from this cemetery had exceptionally diverse, non-local childhood origins (Müldner *et al.*, 2011: 288).

A second study by Montgomery, Knüsel and Tucker (2011) focussed on investigating the origins of six individuals from the Driffield Terrace cemetery. Samples from four decapitated and two non-decapitated individuals were analysed in terms of lead, strontium and oxygen isotope ratio (Montgomery *et al.*, 2011: 141 and 154). Results suggested that two of the decapitated individuals were local, and probably originated from north or east Yorkshire (Montgomery *et al.*, 2011: 167). The remaining four individuals were likely to be non-local, originating from places such as the southwest of Britain, the Mediterranean, and central/eastern Europe (Montgomery *et al.*, 2011: 167).

The aformentioned evidence strongly suggests that the population of *Eboracum* was extremely diverse, consisting of individuals from all parts of the Roman Empire. This mixture of locals and migrants is very likely to have resulted from people being attracted to *Eboracum* for a complex variety of reasons with trade, work, and family being just a few possible motives.

The population of *Eboracum* has also been subject to a study on the biological impact of Roman colonialism in Britain. Joshua Peck's 2009 doctoral study analysed bioarchaeological data from 267 skeletons from pre-Roman Iron Age cemetery assemblages from East Yorkshire, and compared it with the data from 262 skeletons from the Trentholme Drive cemetery assemblage in order to examine the biological and sociocultural effects of urbanisation associated with Roman colonialism on the overall health of the population (Peck, 2009). Results showed that the later Romano-British population had significantly higher rates of pathological conditions indicative of non-specific physiological stress (e.g. increased trauma and joint disease; Peck, 2009) than their pre-colonial counterparts. Oral health also appears to have declined post-contact, suggesting a change in diet (Peck, 2009). Overall the study showed that Roman colonialism had a significant impact on the health status of the population, something that is also likely to have an effect on other aspects of society.

One of the reasons why Roman York has become a focus for bioarchaeological studies in recent years is that a large number of burials have been excavated and recorded from this period. While this is also true of several other urban sites, the majority of these are concentrated in the south of England; York provides us with the main body of evidence for urban populations in the north. The other northern Roman urban settlements such as Chester and Lincoln have so far yet to produce any substantial burial data (as outlined in Chapter 1), and other significant sites further north tend to be military installations rather than towns. With the exception of the fortress and associated settlement at Birdoswald (Wilmott, 1993), the remaining large Roman sites in the north of England and Scotland have produced little in the way of skeletal remains. Therefore, the corpus of Roman burials from York is the largest in the north of England, spanning the majority of the period of occupation and also comprising both military and civilian populations.

2.3. Excavation of the Roman Cemeteries

Archaeological excavation in and around York has shown that burials of Roman date are present on all sides of the Roman town, with a tendency to be clustered around the main roads leaving/entering the settlement. This is a common Greco-Roman practice (Toynbee, 1971: 73; Patterson, 2000: 92-3; Hope, 2007: 141). Figure 2.10 (Müldner *et al.*, 2011: 282) shows the locations of archaeologically known cemetery areas and isolated burials. The observed pattern fits known Roman conventions regarding cemetery location. Roman cultural and religious beliefs (enforced by legislative measures designed to reduce health risks associated with the presence of corpses and practical hazards that may arise from funerary practices such as cremation) meant that it was considered inappropriate and unhygienic to bury the dead within the boundaries of a settlement (Toynbee, 1971: 73; Patterson, 2000: 92-3; Hope, 2007: 129). Figure 2.10 also shows that isolated burials have been found within the settlement, both in the *canabae* and the *colonia*. These burials may represent early interments made before formal establishment of the town boundaries, or alternatively could suggest that demarcation between cemetery areas and the settlement may have been somewhat vague (Jones, 1984: 40).

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Figure 2.10: Known Roman burial areas at *Eboracum* (Müldner *et al.*., 2011: 281, after Ottaway, 2004: 12)

Roman burials have been found in York since the late seventeenth century; possibly the first published reference is of an extensive cemetery containing inhumation and cremation burials at Clifton Fields, in a paper from 1682 published by the Royal Society (Lister, 1682; RCHME, 1962: 73). Since then, hundreds of burial sites (whether excavated or noted as antiquarian findspots) have been documented, many of which are inventoried in the 1962 Royal Commission report.

The two most well-known cemetery excavations took place at the Old Railway Station and at Trentholme Drive (Figure 2.10). Large concentrations of burials dating to the second to fourth centuries were discovered during the construction of York Railway Station and its associated works (e.g. goods lines, engine sheds etc.) between 1839 and 1841, in 1845, and 1870 to 1877 (RCHME, 1962: 77). This burial ground, commonly referred to as the Railway Cemetery, is thought to stretch over 500m south east from the area currently occupied by the National Railway Museum through the current railway station to the location of the Royal York Hotel (Rutledge, 2000: 3). The cemetery would have been located to the immediate north west of the Roman *colonia*. Unfortunately the majority of burials from the Railway cemetery were destroyed and not recorded in any great detail, with only a few skulls kept for curation and study (Jones, 1984: 35).

Romano-British human skeletal remains were excavated at Trentholme Drive by Leslie Peter Wenham and the Ministry of Works between 1951 and 1959 (Wenham, 1968). Remains from this site represent part of the larger “Mount” cemetery. The excavation report estimates that a minimum of 350 individuals from inhumation burials were excavated, as well as a further 53 cremation burials (no estimation of the minimum number of cremated individuals contained in these burials has ever been published, and it is generally assumed that each of the 53 cremation burials represents a single individual: Wenham, 1968). The cemetery was estimated by Wenham (1968: 4) to have been in use from approximately A. D. 140. until the end of the fourth century.

The other main cemetery area excavated, situated on the main road leaving *Eboracum* to the southwest, is The Mount (Figure 2.10). This area comprises many archaeological sites, including those at Micklegate, Blossom Street, Driffield Terrace/Estate, Trentholme Drive, Holgate and Dringhouses, and has been excavated in a rather piecemeal fashion since the nineteenth century (RCHME, 1962: 92-107). The cemetery appears to run for at least half a mile along the line of the main road, although burial density does decrease further away from *Eboracum* (Jones, 1984: 35). Burials, finds, features and deposits of Roman date are frequently found in modern archaeological excavations in this area (MAP Archaeological Consultancy, 1993; Hopkinson, 1998; Palmer, 2002; Johnson, 2004; Kausmally, 2004; Field Archaeology Specialists, 2006b; McIntyre and Holst, 2006).

The Driffield Terrace region of The Mount cemetery has recently been subject to a significant amount of research, due to the discovery of a large group of decapitated burials. Evidence for Roman burials was first found at this location in 2004 during an archaeological evaluation by Field Archaeology Specialists (Spall, 2005). Subsequent excavation revealed 80 inhumation burials from a total of three sites, as well as cremated bone from 20 contexts over two sites, and disarticulated bone from three sites (Tucker, 2006). Of the 80 burials, the majority of which were male, 48 had been decapitated and 20 had evidence of peri-mortem sharp/blunt force trauma consistent with a violent death (Tucker, 2006; Montgomery *et al.*, 2011: 141 and 148; York Archaeological Trust, 2011). A number of explanations have been proposed including that the group are executed criminals or legionary soldiers, or that the assemblage is evidence of a Celtic head cult (York Archaeological Trust, 2011). One popular theory proposes that these burials are the remains of Roman gladiators (York Archaeological Trust, 2011). Detailed archaeological and osteological analysis of these remains is currently awaiting publication by York Archaeological Trust (Hunter-Mann, 2012; pers. comm.).

As well as burials found in the main cemetery/excavated areas, single or small clusters of burials are periodically found in other areas of the town. These are often found on small-scale excavations, evaluations or watching briefs, but nevertheless add to the growing corpus of data relating to *Eboracum*. More recent examples of sites yielding Roman inhumations include the former Starting Gate Public House (excavated routinely in lieu of development), Heslington East (in ongoing excavations by the University of York), and the Yorkshire Museum, where an inhumation was discovered during installation of new plumbing (McComish, 2010; Holst, 2008; 2009; 2010; 2011). The number of Roman burials discovered every year in York is small, but this is at least partially due to factors regarding excavation strategy in an important historic city such as adherence to conservation and planning laws, building regulations, and subsequent changes in building strategy. York is not only a well developed modern city, but is built upon multiple phases of archaeology from all preceding periods. Roman archaeology, being the earliest of these, is also potentially the least accessible. Consequently, archaeological intervention is less likely to uncover Roman deposits. This lack of large scale excavation and potential difficulty in exposing Roman archaeology means that consolidation of seemingly disparate evidence from smaller archaeological works is crucial in furthering our understanding of *Eboracum* and its population.

2.4. Funerary Evidence from *Eboracum*

As well as providing evidence for the establishment and development of the Roman town and fortress, and evidence of the living population, archaeological excavation has also provided evidence for funerary tradition and treatment of the dead. This evidence also gives us further insight into the composition of society during this period, and allows us to assess the extent to which Roman funerary traditions had been imported to this part of Britain.

In the mainland Roman Empire, cremation was the preferred method of burial from approximately the eighth century B. C. until the first century A. D., when inhumation began to gain popularity (Toynbee, 1971: 39-40). Both inhumation and cremation were practised in the first and second centuries A. D., although cremation remained the dominant funerary rite until the third century (Toynbee, 1971: 40; Hope, 2007: 110). Whilst certain characteristics of burial and funerary tradition are likely to have been relatively consistent across the Empire (e.g. preferred mode of burial, burial outside settlement boundaries), others (e.g. funeral customs, presence and type of grave goods etc) are likely to have been subject to regional and chronological diversity (Hope, 2007: 86 and 129; Carroll, 2012). Examples of inhumation burials such as the recent case from the Yorkshire Museum, dated to the period when cremation was the predominant practice, could reflect either personal preference and/or differential cultural tradition. For example, Parisi of East Yorkshire in the pre-Roman Iron Age (Arras culture), were habitually burying their dead in large inhumation cemeteries (Harding, 1974: 113; Dent, 1983; Cunliffe, 2005). Although Arras burials are frequently observed as crouched inhumations, extended inhumations (and other variations) are not unknown (Cunliffe, 2005: 546). Early inhumation burials at *Eboracum* may therefore represent continuation of indigenous (or other non-Roman) funerary tradition; unfortunately, without further supporting evidence, this is very difficult to confirm.

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Figure 2.11: Cinerary urn above earlier inhumation burial SK 201, Trentholme Drive (Wenham, 1968: Plate 5b)

Cremation was the earliest predominant funerary method used in *Eboracum*, being overtaken in the late third century by inhumation burial. This is in alignment with the general pattern observed in Roman Britain, as well as contemporary empire-wide trends (Toynbee, 1971: 39-40; De La Bédoyère, 2003: 168; Hope, 2007: 110). The earliest excavated cemetery is at Fishergate, where cremation burials found from the nineteenth century onwards have been dated to the first and second centuries (RCHME, 1962: 69; Spall and Toop, 2005). The excavation at Trentholme Drive has yielded evidence of both funerary methods being used (Wenham, 1968: 26; Jones, 1984: 38). Several urned cremation burials were found to be stratigraphically later than adjacent inhumations, indicating that the inhumations were interred first (Figure 2.11; Wenham, 1968: 26; 28-32). This evidence has been used to suggest that there was a brief transitional period where both cremation and inhumation were being used shortly before inhumation became the prevailing method of burial. The burial evidence therefore suggests it is unlikely that just one funerary practice was ever exclusively used (De La Bédoyère, 2003: 168).

The dating of burials from *Eboracum* is problematic, making it difficult to establish a precise burial sequence. It is inappropriate simply to date burials as “earlier” or “later” according to their burial type, based on the premise that cremation burials occur earlier and inhumation burials later (Toynbee, 1971: 40). Slightly more precise dating of burials, especially those discovered on older excavations, has relied on the presence of dateable grave goods, coins or pottery typology. Absence of grave goods or surviving artefacts (even on sites where phasing is good; Ottaway, 2005: 66) has led to a large proportion of burials being dated simply as “Roman”; even where pottery, coins or finds do survive, dating still tends to be broad, with burials being categorised approximately according to century (which may also be misleading; Jones, 1984: 36). Radiocarbon dating of more recently excavated burials is beginning to help establish a better burial chronology; for example, the inhumation burial found at the Yorkshire Museum in 2010 has been radiocarbon dated to the late first/early second century, indicating that inhumations did occur during the earlier part of the Roman period in York (Toynbee, 1971: 40; Holst, 2011).

Evidence from excavations at *Eboracum* has been used to make inferences about social status in the population. Burial location does appear to have been linked to social status and wealth in the Roman world, with the most sought after plots being in close proximity to towns and immediately adjacent to the main roads (Hope, 1997; 105; Williams, 1999: 101). Burials in these locations, especially when associated with elaborate stone monuments, would constantly be seen by people travelling in and out of the town allowing the dead to be preserved in the memory of the living (Hope, 1997: 105). The cemetery evidence from *Eboracum* does seem to fit with this premise, especially regarding location of what have been interpreted as the “wealthier” graves (Ottaway, 2004: 122-3; Leach *et al.*, 2009: 547).

The majority of evidence for social status comes from the Old Railway Station, The Mount and Trentholme Drive. The Railway cemetery is generally considered to have been the preferred burial area for the population of *Eboracum*, despite not being situated directly on a main road (potentially the Railway cemetery's close proximity to the town also factored in its popularity). Burials were distributed in an organised fashion, well spaced with little intercutting (Leach *et al.*, 2006: 547). Examples of wealthier burials are located in this cemetery, as well as on The Mount, including individuals (several of non-British origin, e.g. Julia Fortunata from Sardinia and her husband Marcus Verecundius Diogenes, from northern France) with good quality grave goods, stone coffins and more monumental examples of grave markers, tombs and mausolea (RCHME, 1962; Ottaway, 2004: 122-3; Leach *et al.*, 2009: 547). Numerous inscribed stone funerary monuments and grave markers have also been found in The Mount cemetery along the main southwest road (RCHME, 1962; Ottaway, 2004: 122).

Caution must be exercised when interpreting funerary evidence, especially regarding the wealth and status of the individual. Reasons for the inclusion of certain grave goods may extend beyond monetary value, which should not necessarily be equated with status (Struck, 2000: 109-10). Furthermore, wealth and status are not the only factors governing burial options and commemoration (Hope, 1997: 108). Surviving burial markers cannot be used to reconstruct society and status, but instead can be used to draw inferences about how individuals wanted to be remembered after death (Hope, 1997: 109). Therefore, many of the individuals discovered at the Railway and Mount cemeteries may be interpreted as wealthy, but their exact social status is much more difficult to determine.

Trentholme Drive has always been regarded as a cemetery area populated by the lower strata of society. Evidence for this includes lack of permanent grave markers, a deficiency in the quantity and quality of grave goods, general disorganisation in terms of cemetery layout, and substantial intercutting of burials (Wenham, 1968; Ottaway, 2004: 123; Leach *et al.*, 2009: 547). Furthermore, Wenham (1968: 46) suggests that the Trentholme Drive site was located on the "last available dry area" of land connected to the main cemetery on the southwest road and before the waterlogged area at Knavesmire. Locating a cemetery in marshy ground is never ideal, again implying that this area was only used by those “compelled by economic, social, and geographic pressures” (Wenham, 1968: 46).

The absence of grave markers is also problematic when it comes to interpretation of status. Absence of a grave marker may be attributable to a number of causes: failure or refusal to erect a marker, loss of a semi-permanent marker (e.g. of wood or ceramic), or loss of a marker during a later period (e.g. robbing/reuse, damage, or truncation) (Hope, 1997: 107; Struck, 2000: 86). Furthermore, it cannot be assumed that all members of society wanted to participate equally in the same culture of funerary commemoration, or could afford to (Hope, 1997: 108). In addition, Britain did not have a culture of monumental or permanent funerary commemoration prior to the arrival of the Romans, and post-colonisation the number of surviving monuments is very low; it has been estimated that only 2% of burials in Roman Britain have surviving grave markers (Struck, 2000: 86; Mattingly, 2007: 306). The complex set of factors influencing presence and survival of grave markers can, therefore, greatly hinder interpretation.

Problems also arise in trying to distinguish civilian burials from those of the military. Most of the evidence for the presence of military personnel is epigraphic, though again the aforementioned problems relating to the content of inscriptions and survival/presence of grave markers inhibits the amount of insight that can be gained from inscriptions (De la Bédoyère, 2003: 171). As yet, there is no evidence to suggest differential burial of military personnel, or zoning of military burials. The location of epitaphs suggests that a number of soldiers were buried at The Mount cemetery, such as Lucius Duccus Rufinus, a standard bearer of the Ninth Legion, and Lucius Bebius Crescens, a soldier of the Sixth legion (RCHME, 1962: 92; Jones, 1984: 36; Rollason, 1998: 115 and 118). However, The Mount cemetery also contains many civilians, such as Julia Brica, Corellia Optata and Valerius Theodorianus (RCHME, 1962: 95-6; Rollason, 1998: 116-119). The finding of military burials at The Mount is unsurprising considering that this area is one of the main cemetery areas at *Eboracum*. Military epitaphs have also been found at the Railway cemetery, Castle Yard and Clifton (Rollason, 1998: 110-2); the presence of inscriptions at these locations may actually tell us more about the survival of the grave markers than about preferred burial areas for soldiers.

There is also evidence for the re-use of grave furniture. A number of burials have been found where osteological analysis has shown the skeleton to be a different age and/or sex from the individual referred to in the accompanying epitaph. For example, a stone coffin from Castle Yard, bearing an inscription stating that the occupant was a 29 year old female (Julia Victoriana, wife of a centurion of the Sixth Legion) actually contained a mid adult male (RCHME, 1962: 68-9; Rollason, 1998: 110-11; Ottaway, 2004: 141). Similarly, an inscription found on the lid of a coffin found at Dalton Terrace stated that the occupant was a 27 year old female (Aelia Severa), when in fact the associated skeleton was male (RCHME, 1962: 128; Norman, 1971: 152; Rollason, 1998: 121; Ottaway, 2004: 141). No osteological evidence of the individuals noted in the accompanying inscriptions was found in either case.

It should be noted that potential confusion can arise when trying to identify biological sex using epigraphic records. Fortunately at York, where names are present in inscriptions, identification of sex is fairly straightforward. However, absence of a name could give rise to confusion. For example, in carvings on late Roman sarcophagi, male and female figures are often depicted occupying a position or stance that at an earlier date would have been associated with the opposite gender (Huskinson, 2002: 205). In cases like this (particularly if the date of the inscription is not know, it is possible that the apparent gender could have been mis-represented or mis-interpreted, resulting in epigraphic evidence for gender and osteological evidence for biological sex becoming mismatched.

Ottaway (2004: 140-1) suggests that reuse of coffins and disturbance of such burials and other funerary monuments may be related to the destruction of the temples that apparently occurred in the late fourth century. Desecration of the grave was considered extremely taboo in Ancient Rome, so disturbance of remains could be associated with a period of turmoil where normal customs were less likely to be observed (Ramm, 1971: 188; Hope, 2000: 122-3). Jones (1984: 36), however, states that the disturbances at *Eboracum* should not be over interpreted, as the number of burials affected is very small.

Evidence for post-mortem treatment of the body has also been found at *Eboracum*, with significant quantities of burials having been treated using gypsum. Gypsum is a soft mineral (calcium sulphate) found in the Permian, Triassic and Jurassic geology of Nottinghamshire, Staffordshire and Leicestershire (Philpott, 1991: 90; British Geological Survey, 2006). Although gypsum was clearly being used in funerary treatments in Britain during the Roman period (particularly in the fourth century), and gypsum is found in British geological deposits, there is currently no evidence to suggest that the mineral was being mined in Britain during the Roman period. This indicates the material is highly likely to have been imported from elsewhere in the Empire (Philpott, 1991: 91; Sparey-Green, 2005: 102).

Approximately 60 burials from *Eboracum* have been found where the body or skeletal remains have been coated in gypsum (RCHME, 1962; Holst, 2008b: 7). It is presumed (based on evidence from both *Eboracum* and Poundbury) that liquid gypsum would be poured into the coffin over the body, for the purpose of preserving the remains or possibly to prevent grave robbing (Salway, 1981: 700; Alcock, 1996: 45). Evidence of Roman gypsum burials has also been found in London, Kent and Dorset in the UK, the Rhineland and North Africa, with the practise possibly originating in Carthage (Ramm, 1971: 189; Sparey-Green, 2005: 101). Similarities between the gypsum burials at York and others found in Algeria may again be indicative of the presence of North Africans in *Eboracum* (Ramm, 1971: 189).

The presence of a seemingly high proportion of decapitated burials at sites around Driffield Terrace has raised questions as to why the affected group of individuals had been treated in this way. Although decapitation has come to be regarded as fairly normative in late Roman Britain, rates at Driffield Terrace have been described as excessively high (Harman *et al.*, 1981: 163; Boylston *et al.*, 2000: 241; Montgomery *et al.*, 2011: 151). The other difference between the Driffield Terrace skeletons and other known assemblages is the fact that the individuals from York are primarily adult males, whereas with other known examples both sexes are well represented and sub-adult burials are also present (Boylston *et al.*, 2000: 141).

Decapitation in the Roman period has generally been associated with social outcasts; this and other disrespectful treatments of the corpse post mortem were typically reserved for people being punished or people whose occupation was regarded as shameful or “polluted” by death (e.g. criminals, prostitutes, actors, undertakers, gladiators; Bodel, 2000; Hope, 2000: 118; Retief and Cilliers, 2006: 136-7; Montgomery *et al.*, 2011: 168). This may suggest that the Driffield group fall into one of these categories. However, association with any of these groupings may also suggest low social status, whereas the Driffield group are buried in a cemetery location synonymous with individuals of high status (Montgomery *et al.,* 2011: 168). Furthermore, the Driffield burials all appear to have been treated respectfully, with the bodies and heads kept together and positioned carefully in the grave (Montgomery *et al.,* 2011: 168). The character and position of the Driffield burials does not particularly suggest that these individuals were treated with indignity, as may be expected with social outcasts (Harman *et al.*, 1981: 168). Whatever their status, close proximity of these burials and comparable peri-mortem treatment suggests these burials may represent a specific social/cultural group whose identity continued to be expressed after death. However, the precise relationship between expression of identity and funerary rite/treatment is usually complex and caution should be exercised so as not to grossly oversimplify it (Williams, 1999: 101; Pearce, 2000).

2.5. Summary

Archaeological and historical evidence shows that while *Eboracum* may have been founded as a military outpost, it rapidly developed into a cosmopolitan urban settlement with a diverse population. Later decline of the town is likely to have been the consequence of political turmoil elsewhere in the Empire, with extraction of troops and subsequent deterioration of public works leading to a re-ordering of society and a reduced population. Archaeological study of *Eboracum* has provided valuable insight into human activity at the site during this period, although substantial areas are yet to be investigated to depths that could reveal information about the Roman town. The funerary evidence suggests considerable cultural influence from Rome and its provinces, particularly North Africa.

This chapter documents both the history of Roman period York and the history of archaeological study of the town during this time period, therefore contextualising the population examined in the present study. Although a significant number of Roman burials have been excavated and recorded in and around York, only a small proportion of these have been studied in any detail, and until the present study a comprehensive review has never been conducted. Furthermore, this chapter highlights that the understanding and interpretation of the archaeological and historical evidence from Roman York has changed and developed since formal study of the town began in the post-medieval period. This chapter therefore emphasises the necessity for this human skeletal assemblage to undergo further study, in light of new archaeological discoveries and interpretations. The next chapter will describe the exact materials that constitute the skeletal samples considered in the present study, discuss the reasons why specific material was selected for study, and consider the precise methodologies used in analysis of the material.

Chapter 3: Materials and Methodology

This chapter describes the materials and methods used to investigate the research questions outlined in Chapter 1. The materials section includes an explanation of how the study area was defined and a summary of the available skeletal assemblages, as well as the published data for assemblages that are no longer available for research due to reburial, curatorial loss or withdrawal of research access by curatorial organisations. The methods section describes the protocols and procedures used for recording and analysing the data including the recording of the completeness and preservation of skeletal remains, demography, dietary reconstruction, and health status.

3.1. Materials

Occupation of what would become the Roman town of *Eboracum* began in A. D. 71 (Hartley, 1980: 4; Addyman, 1984: 14; Roskams, 1999: 50; Ottaway, 2004: 31; see Chapter 2). The end of the Roman occupation in York is considered to be approximately A. D. 410 (Addyman, 1984: 16, Brinklow, 1984: 27, Ottaway, 1999: 149). Therefore, the time period covered by this study is A. D. 71-410. It should be noted, however, that many burials classified as “Roman” were not dated by the present author, so this study relies on dates established by both published and unpublished sources. Many burials used in this study have been assigned approximate dates based on spot dating of associated finds, site stratigraphy or archaeological phasing, as well as more precise dates established via radiocarbon dating. Systematic precision dating of all burials is beyond the remit of this study, largely due to the time and expense that this would incur. Therefore, only burials that were confidently dated (archaeologically, stratigraphically, radiocarbon dated etc.) to the period of Roman occupation of York were utilised.

There is a lack of osteological material suitable for this study that dates to the early Roman period in Britain (i.e. the first and second centuries). This applies both to osteological assemblages from York and other urban settlements from elsewhere in the country. Of the observed sites from York, only seven sites had burials that are likely to date to the first century. Of the comparative assemblages utilised for this study (see below), only two (from London and Gloucester) yielded burials that dated to the first century. Two comparative sites (Derby and Dorchester) have burials that, at the earliest, date to the mid-second century, although these sites continue to be used until the mid-fourth to early fifth centuries. The small quantity of very early material limits the amount of meaningful results that may be acquired from detailed temporal analysis.

Furthermore, it was initially intended that where possible, archaeological samples (both for York and comparative urban sites) would be divided into cremation burials (representing earlier burials) and inhumation burials/unburnt disarticulated bone (representing later burials). However, this crude division of individuals according to burial type does not take into account the period of overlap where both burial rites were clearly in use simultaneously. In addition, this division does not allow for regional variation in change of burial type. For example, while cremation burial was only the predominant funerary practice until approximately the second century in York (Ottaway, 1993: 92), archaeological evidence has shown that this method persisted in other areas of Britain until much later. For example, the Romano-British cremation cemetery at Brougham in Cumbria dates to the third century (Cool, 2000). The lack of secure dating for the majority of the York assemblage means that it is very difficult to divide the sample according to burial date. The majority of dated burials have a very wide date range that overlaps two or more centuries, while the bulk of burials overall are simply dated as “Roman”. It would be preferable to divide demographic analysis into two chronological periods; the first with early Roman burials from the first and second centuries, and the second with later Roman burials from the third to early fifth centuries – however this method is not applicable to the available material. Imposition of these divisions would result in two very small dated samples from which little in the way of meaningful inference could be drawn, and one large “Roman” period sample. Therefore, the lack of early material, coupled with the imprecise or broadly dated nature of many of the relevant assemblages, means that for both York and the comparative material, all burials spanning the time period A. D. 71-410 will be considered together.

Roman human skeletal material has been discovered in and around York since the late seventeenth century. This includes human skeletal material from articulated inhumation burials, cremation burials and disarticulated material. This study aims to collate osteological data for all known, accessible material found from the seventeenth century up until the present day. This includes material found at sites ranging from antiquarian findspots and construction projects through to modern commercial archaeological intervention such as watching briefs, borehole surveys, and archaeological evaluations and excavations.

The geographical area of study was established to encapsulate the town of *Eboracum* and its immediate associated hinterland. A 1: 50,000 scale raster Ordnance Survey map (map tiles SE 44 and 64) was downloaded from OS Open data (Ordnance Survey, 2011). The location of the fortress at *Eboracum* was plotted on this map in ArcGIS 9.3. A circular study area, of 5km radius was then plotted on the same map, from the centre of the fortress. The fortress at *Eboracum* was located centrally in the town: centralising the study area around the fortress therefore locates *Eboracum* in the centre of the study area. A radius of 5km was chosen in order to capture all burials likely to have been associated with the population of *Eboracum*. The study area measured 78.54km^2, with a circumference of 31.42km, and is presented in Figure 3.1.

Although large, a study area of this size is necessary: archaeological evidence indicates that Roman York drew heavily on provisions from a wide surrounding region. For example, environmental evidence suggests that hay was brought in from at least 15km away (Roskams, 1999: 66); and faunal evidence suggests that some animals reared for meat were raised at least 20km away (O’Connor, 1988 and Dobney, 1999: 22). However, it is unlikely that many burials directly associated with the settlement at *Eboracum* would be located this far away from the town. Indeed, burials around Romano-British towns tend to cluster relatively closely to settlements: for example at Gloucester, the main cemetery areas fall within a 2km radius of the town edge (Simmonds *et al*., 2008: 3); at St Albans, these areas fall within 1.5km of the town boundary (Niblett, 2000: 97).

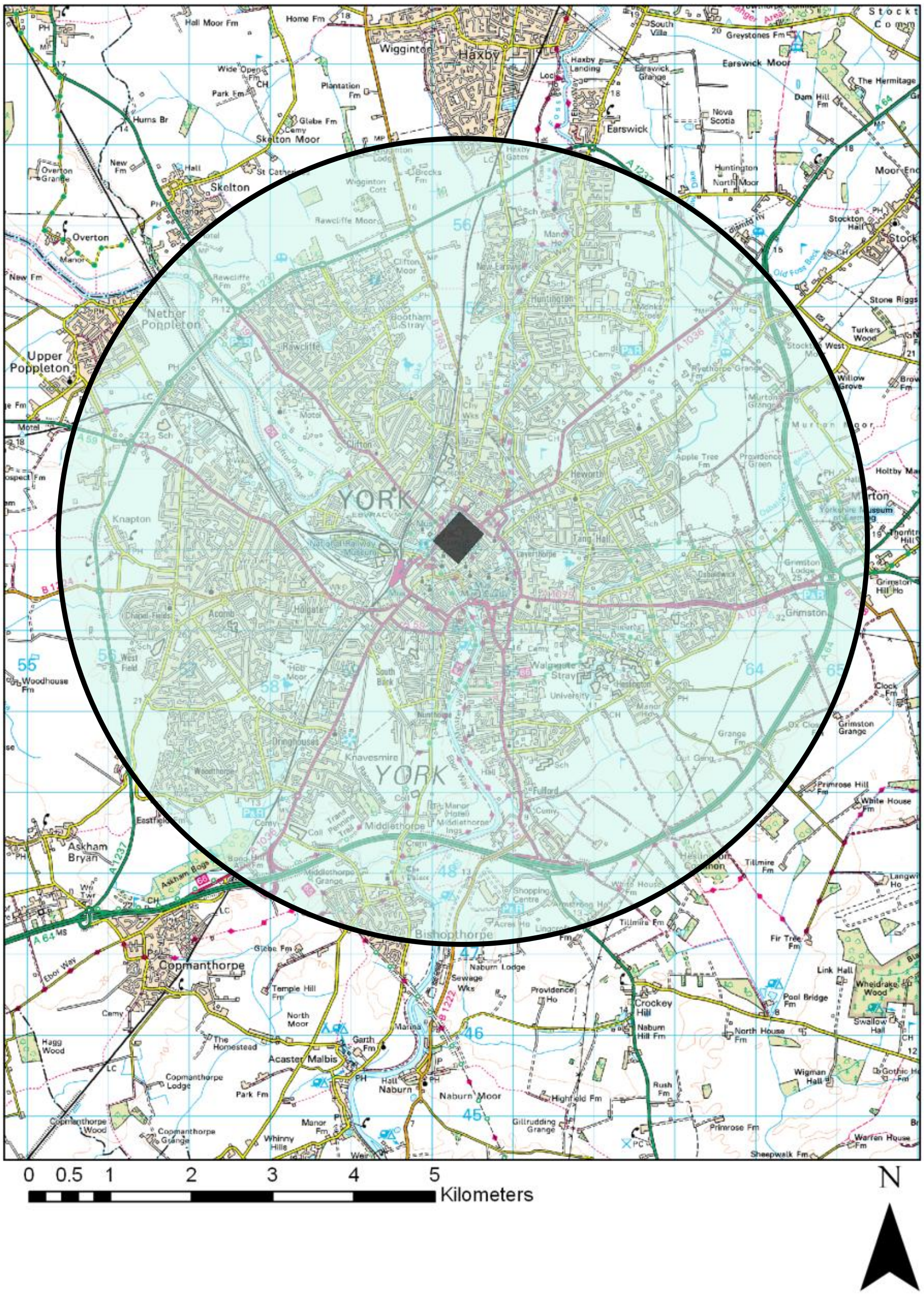

Figure 3.1: The total study area

Trailing burials are a common finding at Roman cemeteries in Italy, where single rows of tombs and monuments are often found bordering main roads for miles outside cities such as Rome and Pompeii (Toynbee, 1996: 73). Presumably these single-file monuments were erected by people wanting a roadside monument but who could not afford to buy a plot nearer to the town, or where affordable areas closer to the town no longer had sufficient roadside space. Seemingly isolated burials made even further away from urban settlements are more likely to be associated with the isolated farmsteads and/or small villages that would have been located between larger settlements. Therefore, a study area of the size used in this project is likely to encompass both the main cemetery areas and straggling roadside burials still associated with *Eboracum*, while limiting the possibility of catching isolated burials related to other nearby settlements such as the fortresses at Newton Kyme to the south west or Malton to the north east.

Once the geographical area of study was established, a site database was compiled listing all known sites yielding human skeletal remains of Roman date. The database was produced in Microsoft Excel 2007 from the following sources: Archaeology Data Service (2011); the Archaeological Investigations Project Gazetteer at the University of Bournemouth (2010); City of York Council Sites and Monuments Record; City of York Historic Environment Record; Heritage Gateway (2006); North Yorkshire Historic Environment Record; Pastscape (English Heritage, 2007); the Claire Rawlings database (compiled for York Osteoarchaeology Ltd. in 2008 as part of a Masters dissertation at the University of York); and the Royal Commission on Historical Monuments (England) inventory of the historical monuments in the city of York (1962). A search was also made through the *Yorkshire Archaeological Journal* series. Furthermore, personal enquiries and study visits were made to local museum services, commercial archaeological units, and the University of York. A total of 94 sites yielding 785 discrete Roman individuals were found (Figure 3.2).

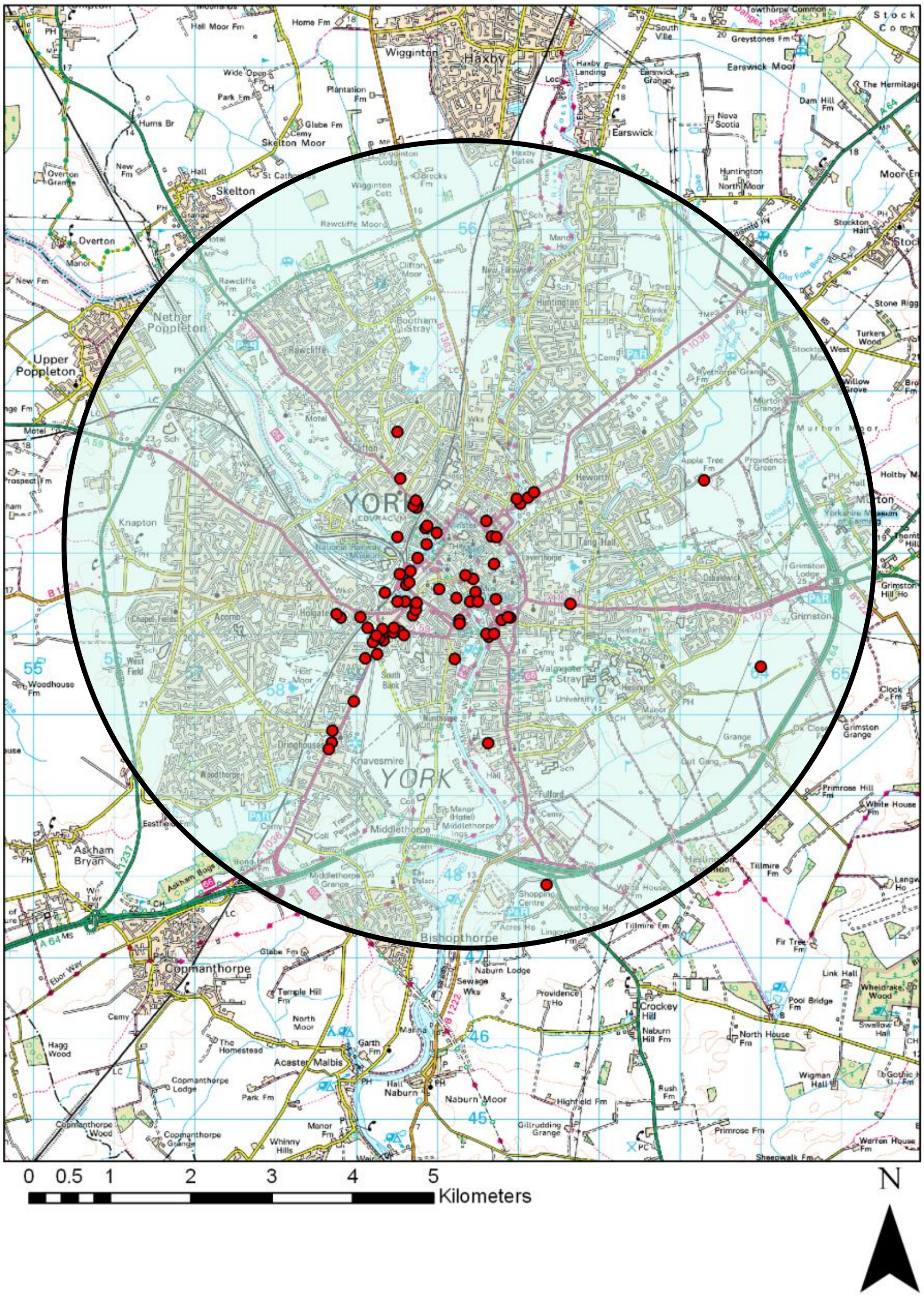

Figure 3.2: Locations of sites utilised in this study (Close proximity of some sites in combination with the map scale may have led to some sites overlapping)

As far as possible, information collected for each site included a unique record I. D. (e.g. site code), site name, the individual or organization responsible for the excavation, level of archaeological intervention, date of archaeological intervention, number of inhumation burials, cremation burials or disarticulated contexts found, national grid reference, and current location of any human skeletal remains or archival material. National grid references were checked to make sure that the given point correctly corresponded with the site location. All sites are listed in a gazetteer in Appendix 1.

Once an exhaustive list of sites was made, osteological data were collected for each site. In the majority of cases this involved acquiring published or unpublished archaeological and osteological reports. If no report was available, the appropriate archive was investigated for unpublished site notes, and archaeological and osteological records. If no written archive was available, or the required data not available, it was ascertained whether the skeletal material was still accessible. If so, the author obtained permission to study the material and recorded the necessary osteological data. Recording techniques and methods are discussed below. Where no written archival material or human skeletal material was available or accessible (e.g. in the case of inadequate on-site recording and subsequent reburial) the site was omitted from the study (see Appendix 2 for a full list of omitted sites). In some cases, gazetteer entries on databases such as Pastscape (English Heritage, 2007) referred to a general area where inhumations had been found or observed historically, or to known Roman cemeteries (e.g. “The Mount” cemetery situated just outside the Roman *colonia*, situated on the main Roman road connecting York and Tadcaster). In these cases, if the gazetteer entry did not specifically refer to a known, traceable assemblage of human skeletal material, it was omitted from the study.

Osteological data in the form of published or unpublished reports were collected from a number of institutions that have conducted archaeological work in the area of study: Brigantia Archaeological Practice; City of York Sites and Monuments Record; Field Archaeology Specialists; MAP Archaeology; Mike Griffiths and Associates; Northern Archaeological Associates; On Site Archaeology; the University of York; West Yorkshire Archaeology Services; York Archaeological

Trust; and York Osteoarchaeology Ltd. Access to human skeletal remains currently kept in storage was granted by: Prof. Don Brothwell at the University of York; Harrogate Museum; Leeds Museum and Galleries; York Archaeological Trust; and the Yorkshire Museum. A small amount of human skeletal material is curated by Museums Sheffield, but at the time of data collection it was not available for analysis. Table 3.1 shows the number of discrete individuals examined by the present author, and the number where data were taken from the aforementioned reports. It should be noted that data for eight inhumation burials were taken from two reports by the present author (McIntyre, 2007 and Bruce *et al*., in prep), from analyses completed prior to the present study. Furthermore, data for the skull of one skeleton from Sycamore Terrace (the Ivory Bangle Lady, SK YORYM 1977.60) was taken from a publication (Leach *et al*., 2010), whereas data for the post-cranial skeleton was collected by the present author. This skeleton is included in both sections of Table 3.1.

Examined by the Present Author			**Data Collected from Reports and Publications**		
Inhum. Burials	**Crem. Burials**	**Disarticulated Contexts**	**Inhum. Burials**	**Crem. Burials**	**Disarticulated Contexts**
166	9	37	492	69	217

Table 3.1: Number of discrete individuals examined by the present author vs. data collected from reports and publications

One substantial cemetery site, Trentholme Drive, proved difficult to include in the study because of the way that the collection is curated and the nature of previous work carried out on it. Since publication of the 1968 report by Wenham, the human skeletal remains were divided and deposited at both the Natural History Museum in London, which holds the majority of the assemblage, and the Yorkshire Museum in York, which holds a small part of the assemblage including a number of skeletal elements affected by pathological lesions. Regrettably, many of the remains have undergone re-numbering during the mid- to late twentieth century, and many of the current Natural History Museum skeleton numbers can no longer be matched to skeleton numbers given in the Wenham report. A number of recent studies have utilised remains from the Trentholme Drive assemblage (e.g. Müldner and Richard’s 2007 study of dietary patterns in York, and the Leach *et al.* 2009 study of migration and diversity in Roman York), the nature of the research conducted in these studies means that only a sample of this assemblage was required. Re-numbering and division of the assemblage has significantly lessened the research potential of such a large population sample.

Until recently, the Trentholme Drive assemblage had not been comprehensively re-appraised osteologically since its initial analysis for the 1968 report. In 2009, 262 individuals from the Natural History Museum were re-analysed in terms of age, sex, stature, and dental/non-dental pathology as part of a PhD thesis investigating the bioarchaeological impact of Roman colonisation in Britain by Joshua Peck (2009). Both the Wenham (1968) data and the Peck (2009) thesis are of limited applicability to this study. While Peck’s (2009) demographic data for the sample of 262 individuals is comprehensive and easy to combine with other data collated for this study, skeletal inventories are only available for the long bones, clavicles and first and second molars, with cranial vault presence being scored as a percentage (Peck, 2011, pers. comm.). Furthermore, only a limited number of pathological lesions were recorded. This causes problems for the purposes of this study, where it is imperative that both affected and unaffected skeletal elements are quantified in order to calculate pathological prevalence rates. This limitation is also true of the Wenham (1968) report, where pathological lesions are noted but only an approximate description of the skeletal elements present are given for each individual (e.g. skeletons are described as “fairly complete”, “almost complete” or given a rough description such as “vertebrae from mid thoracic, pelvis and legs”; Wenham, 1968: 129-145).

In the light of their limitations, the intention was to analyse the Trentholme Drive material for this study. Unfortunately, the size of the assemblage, coupled with the added complication of the individuals being re-numbered, and given the time and financial constraints of this project it was not possible to conduct this level of research in London. Yet, despite the variable quality and partial availability of data for the Trentholme Drive assemblage, it would be insufficient and inappropriate to conduct a study on the population of Roman York and entirely discount such a large and notable sample of the excavated material. Therefore, human skeletal material from Trentholme Drive accessioned and stored at the Yorkshire Museum, which was available for analysis was examined using the methods outlined below. Demographic data for the sample of 262 individuals from the assemblage was utilised from the Peck (2009) report as this study employed current, standardised osteological methods and included the majority of the assemblage. Efforts were made by the present author to match data for numbered individuals from the Trentholme Drive at the Yorkshire Museum with numbered individuals from the Peck (2009) report. This was possible in the majority of cases, with only a minimum amount of material (where numeric identification data was poor) not being matched. The study incorporated pathological data collected by the author and from the Peck (2009) report where applicable.

3.2. Comparative Materials

Published data from excavations at 11 Roman sites from Britain were chosen for comparison with the York data: Ancaster (*Causennae*) in Lincolnshire, Brougham (*Brocavum*) in Cumbria, Cirencester (*Corinium Dobunnorum*) and Gloucester (*Glevum Colonia*) in Gloucestershire, Colchester (*Camulodunum*) in Essex, Derby (*Derventio Coritanorum*) in Derbyshire, Dorchester (*Durnovaria*) in Dorset, Dunstable (*Durocobrivis*) in Bedfordshire, London (*Londinium*) in Greater London, St. Albans (*Verulamium*) in Hertfordshire and Winchester (*Venta Belgarum*) in Hampshire (Figure 3.3).

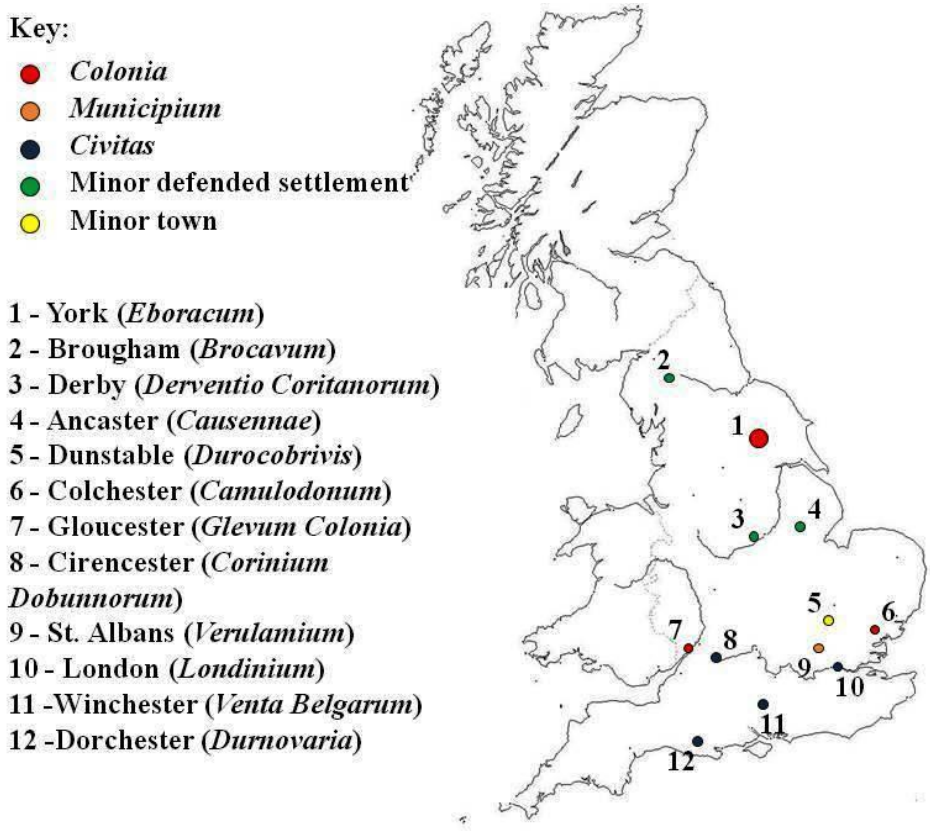

Figure 3.3: Settlement distribution map

Comparative sites were chosen on the basis of sample size (data available for more than 100 individuals), quality of data, accessibility of osteological and archaeological data for burials dating to the appropriate period of study, and the possession of significant urban settlement or military installation status during the period covered by the study. Colchester, Gloucester and Lincoln were all granted the status of *colonia* like York (Dobney *et al.*, 1999: 15), although there is very little osteological data available for Lincoln. Current archaeological evidence suggests that London may also have had *colonia* status (construction of a rather grand, outsized basilica and forum complex in the second century has been used as evidence of the town of London attaining elevated, perhaps *colonia*, status; Mattingly, 2007: 275). While this has not been conclusively determined, it is certain that London was a significant settlement with high urban status, and it may also have served as provincial capital (Mattingly, 2007: 268 and 274-5). St. Albans had the status of *municipium*, (a Roman urban community formed from an existing, native settlement, including alteration of the political system to one based on Roman law) (De la Bédoyère, 2003: 71; Bennett, 2001: 10). Cirencester, Dorchester and Winchester had the status of *civitas*, where existing indigenous tribal settlements were formalised by the Roman state (De la Bédoyère, 2003: 19; Hurst, 2005: 293, Wacher, 1974: 26, 280 and 289). Brougham had both a small fort and a *vicus* a small, provincial settlement usually associated with a military installation (Bell and Cool, 2003). Both Derby and Ancaster are known to have had both a fort and small associated towns (Birss and Wheeler, 1985; Burnham and Wacher, 1990: 235). Finally, Dunstable was a minor town that began as a posting station to the north of *Verulamium* (Matthews, 1981: 60). A summary of data from each site (including the name of the cemetery and associated town, date of cemetery use, total number of individuals and publication reference) can be seen in Table 3.2. At Dorchester and London, data from more than one cemetery were combined in order to produce a larger sample and better represent the original overall population of the town.

Site	**Excav. By**	**Excav. Date**	**Date**	**No. Crem.**	**No. Inhum.**	**Total Individ.**	**Reference**
Ancaster	Nottingham University	1964-73	Late 3rd-4th c.	0	282 (discrete inhumations excavated)	**327** (MNI after osteological analysis)	Cox, 1989; Rayner, 2011
Brougham	Ministry of Public Buildings and Works	1966-7	3rd c.	290	0	**290**	Bell and Cool, 2003
Bath Gate Cemetery, Cirencester	Cirencester Excavation Committee	1969-81	4th-5th c.	3	405 (discrete inhumations excavated)	**424** (MNI after osteological analysis)	McWhirr *et al.*, 1982
Butt Road, Colchester	Colchester Archaeological Trust	1976-79; 1986; 1988	Late 3rd-late 4th c.	5	728	**733**	Crummy *et al.*, 1993
Derby Racecourse, Derby	Derby City Museum; Trent Valley Archaeological Research Committee	1978-79; 1983	Mid 2nd-mid 4th c.	39	73	**112**	Wheeler, 1985; Birss and Wheeler, 1985

Table 3.2: Comparative archaeological assemblages

(continued on page 69)

Site	**Excav. By**	**Excav. Date**	**Date**	**No. Crem.**	**No. Inhum.**	**Total Individ.**	**Reference**
Poundbury, Dorset (Dorchester)	Dorset Natural History and Archaeological Society; Dorchester Excavation Committee	1966-87	Late 2nd-4th c.	0	1388	**1388**	Farwell and Molleson, 1993
Alington Avenue, Dorchester	The Trust for Wessex Archaeology	1984-87	Mid 2nd-4th c.	3	91	**94**	Davies *et al.*, 2002
Little Keep, Dorchester	Wessex Archaeology	2007	Late Roman	0	29	**29**	Egging Dinwiddy, 2009
Icknield Street, Dunstable	Manshead Archaeological Society of Dunstable	1967-81	3rd-early 5th c.	0	112	**112**	Matthews, 1981
120-122 London Road, Gloucester	Oxford Archaeology	2004-06	1st-4th c.	12	154	**166**	Simmonds *et al.*, 2008
Eastern Cemetery, London	Museum of London Archaeology Services	1983-90	Late 1st-4th c.	136	550	**686**	Barber and Bowsher, 2000
Southern Cemetery, London	Department for Greater London Archaeology; Museum of London Archaeology Services	1973-96	Early 1st-late 4th c.	0	46	**46**	MOLA Centre for Human Bioarchaeology, 2009a
Western Cemetery, London	Department of Urban Archaeology; Museum of London Archaeology Services	1979-97	Early 1st-early 5th c.	0	137	**137**	MOLA Centre for Human Bioarchaeology, 2009b
St. Stephens, St. Albans	Verulamium Museum	Late 1980's-early 1990's	Early-late Roman	297	27	**324**	McKinley, 1992
Lankhills, Winchester	Winchester Excavations Committee and Winchester Schools Archaeological Committee; Oxford Archaeology	1967-72; 2000-05	4th c.	32	751	**783**	Clarke, 1979; Booth *et al.*, 2010
Total				**817**	**5073**	**5890**	

Table 3.2: Comparative archaeological assemblages (continued from page 68)

3.3. Methodology

3.3.1. Recording

All osteological recording of the skeletal remains conducted by the author followed the standards and guidelines in Brickley and McKinley (2004). University of Sheffield pro forma skeletal inventory and recording forms were completed for each articulated individual and each cremation (see Appendix 5). Disarticulated material was quantified per skeletal element, with observations made about age, sex, pathological evidence and so on where possible. Precise recording methods will be discussed in more detail below.

Individual articulated skeletons were assessed in terms of completeness and levels of bone preservation. For completeness, the approximate percentage of skeletal elements present was assessed. For bone preservation, each individual was assigned an average preservation score (bone surface and cortex) for the whole skeleton. Preservation scores given were on a scale of 0-5+ after Brickley and McKinley (2004: 16).

Measurements of maximum length were taken on complete long bones using an osteometric board in order to determine stature. Stature was estimated according to Trotter (1970), using combined maximum lengths taken from the femur and tibia. When measuring the maximum length of the tibia, the intercondylar eminence was excluded: the Trotter (1970: 74) method of stature estimation defines the maximum tibial length as measured from the tip of the medial malleolus to the most proximal part of the lateral condyle, although a study by Jantz *et al*. (1995) indicates that tibial lengths included in the Trotter calculations were measured inconsistently, with a number of examples measured to include the intercondylar eminence. In this study, where both the femur and tibia were unavailable, stature was calculated using the maximum length of other long bones in the following order of preference: femur, tibia, fibula, humerus, ulna, and radius. Where both left and right relevant bones were present, stature was calculated using the average length of the two bones. Where the sex of the individual was unknown, the mean of the male and female estimated statures was recorded.

The MNI was calculated separately for inhumation burials, cremation burials and disarticulated material. For the disarticulated material, MNI was calculated based on the maximum number of left femora present, as these were the most commonly occurring skeletal element. For cremation burials, MNI was calculated based on the number of discrete deposits. No evidence was found by the present author for repeated presence of skeletal elements that may indicate the presence of more than one individual, either in cremated deposits examined by the author, or in data from reports collated for this study. Similarly, the number of inhumation burials was calculated based on data for 663 discrete interments.

Observations of sex were made, where possible, by observing sexually diagnostic traits of the pelvis and skull (Phenice, 1969; Ferembach *et al*., 1980; Schwartz, 1995: 40-78; 90 and 124-9). Individuals were sexed as male (“M”), male? (“M?”), indeterminate (“??”), female? (“F?”) or female (“F”). Typical accuracy for sex assessment in adult skeletons from morphological traits is 90-95% when using the pelvis, and 80% when using the skull (Krogman and Işcan, 1986). Higher levels of accuracy are achievable using discriminant function analysis of skeletal measurements, but this was not used here as it was considered too time consuming for the purposes of this study. Sub-adult skeletons were not sexed as many of the available methods are unreliable, do not produce consistently accurate results across different populations, and are often difficult to reproduce (Molleson *et al.*, 1998; Loth and Henneberg, 2001; Vlak *et al.*, 2008; Wilson *et al.*, 2011). Higher levels of accuracy can be achieved by using discriminant function analysis of skeletal measurements (e.g. maximum diameter of the femoral head), but this was not used here, as excellent preservation levels are required in order to gain highly accurate measurements and the skeletal material from York was of varying quality. Furthermore, higher proportions of individuals in any one population can be sexed using morphological rather than metric traits. If no pelvis or skull fragments were available then these metrical data were used to estimate sex (Steele and Bramblet, 1988; Bass, 1971). If no sexually diagnostic traits or metrics were available, the individuals were sexed as “unknown”.

Age estimations were undertaken for adults using multiple aging techniques. Methods applied include the Lovejoy *et al.* (1985) auricular surface method (also utilising unbiased mean age estimates calculated by Gowland and Chamberlain, 2005), the Suchey-Brooks (Brookes and Suchey, 1990) pubic symphysis method, the Meindl and Lovejoy (1985) cranial suture fusion method, and also age estimation by observing dental occlusal surface wear (Miles, 1963; Smith, 1984). Age estimations were made for sub-adults using the Moorees *et al.* (1963) dental development method, the Maresh (1970) method of age estimation via diaphyseal length, epiphyseal fusion times (Scheuer and Black, 2000), and Fazekas and Kósa’s (1978) method of age estimation via foetal diaphyseal length.

Pathological observations were made and interpreted, initially, in accordance with Aufderheide and Rodriquez-Martin (1998), and then with reference to a variety of relevant publications as part of a full differential diagnosis. Ante-mortem pathological lesions were recorded descriptively, and in terms of presence/absence and anatomical location, after Roberts and Connell (2004) and Steckel *et al.* (2006). The principal pathological conditions recorded include trauma, congenital conditions, circulatory disorders, joint disease, infectious disease, haematological disorders, neoplastic conditions, dental pathologies, and any miscellaneous pathology.

Where evidence of traumatic injury was observed, the type of fracture (e.g. comminuted, spiral, transverse etc.) was noted where possible. Bones were not radiographed due to time constraints; therefore only macroscopic observation of fractures was possible. Therefore, where the degree of healing had obscured the original fracture line, the type of fracture could not always be determined. Evidence of healing, and complications to the fracture (e.g. non-union, bone necrosis, secondary infection or joint disease) were also noted, as well as whether the injury was ante-, or peri-mortem.

Where evidence of dislocation was observed, the affected joint was recorded; observable changes to the joint surfaces were noted (as well as any further associated injury). Where possible, it was determined whether the joint was dislocated congenitally or traumatically.

Presence of spondylolysis was recorded in terms of being bilateral or unilateral, as well as noting any evidence of healing or associated defects.

Lesions associated with peri-mortem trauma were recorded by type (i.e. sharp force, blunt force or projectile, as outlined by Boylston, 2004), with sharp force trauma being subdivided into evidence of decapitation and other sharp force injury. It should be noted that vertebral injuries were classified as sharp force blade injuries rather than decapitation when there was insufficient evidence to suggest that the head had been fully severed from the rest of the body.

Clinically, spina bifida occurs when the caudal end of the neural tube fails to close during foetal development, resulting in in the spinal cord and and nerve roots being displaced (Barnes, 2008: 348). The neural arches of the adjacent vertebrae develop incorrectly as a result (sometimes with slowed growth because of the displaced soft tissues), with the spinous processes often failing to develop at all (Barnes, 2008: 348). Spina bifida cystica is the more severe manifestation of the condition, where the neural tissue is exposed to the environment and a large cyst is produced to cover the affected area (Kumar and Tubbs, 2011: 21). Spina bifida occulta does not produce a visible cyst as the neural tissues have not become exposed; this is usually the result of a more minor neural tube defect (Barnes, 2008: 348; Kumar and Tubbs, 2011: 21).

Osteologically, spina bifida is often recorded where the spinous processes of the vertebrae are not present, leaving the neural arch unfused; this is most commonly observed in the lower lumbar, sacral and coccygeal vertebrae (Barnes, 2008: 348). However, as the soft tissue abnormalities associated with neural tube defects cannot be observed osteologically, it is often unclear whether non-union of the neural arch is evidence of spina bifida or is simply representative of a cleft neural arch without the associated neural tube defect (Barnes, 2008: 348).

No cases of spina bifida were observed by the present author: all observed examples came from unpublished reports, or osteological archive notes (MAP Archaeological Consultancy, 2008: 67; Tucker, 2005). One case of spina bifida was diagnosed at 41 Piccadilly, as the skeleton manifested “non-fusion of the posterior part of the lower sacral vertebrae" (MAP Archaeological Consultancy, 2008: 67). The remaining individuals, from sites along Driffield Terrace, were also noted as exhibiting non-union of the posterior sacrum, although no explicit statement was made to confirm whether non-union was observed in all sacral vertebrae.

The term "sacralisation" refers to a developmental anomaly where the last lumbar vertebra is fused to the sacrum, effectively becoming the first sacral vertebra (also referred to as "transitional vertebrae": Barnes, 1994: 108-13). Where this occurs, the sacralised vertebra is typically the fifth lumbar (L5) vertebra, although in some circumstances in this study, a sixth lumbar (L6) vertebra was also present and sacralised. This defect may be partially or wholly fused, symmetrical or asymmetrical, and unilateral or bilateral (Barnes, 1994: 108; Ortner, 2003: 463). In the present study, sacralisation was recorded when observed as present; the name of the involved skeletal element (i.e. L5 or L6) was also recorded. No examples of lumbarisation (where the first sacral vertebra is detached to effectively become the last lumbar vertebra: Barnes, 1994: 110) were observed.

Osteoarthritis is diagnosed in human skeletal material by the presence of osteophytes (located on joint margins), destruction/reaction of subchondral bone (e.g. eburnation, or polishing of the joint surface, sclerosis), erosion/destruction of the joint surface (e.g. pitting), and changes in the contours of the joint (Rogers *et al.*, 1987: 185; Ortner, 2003: 545). Where subchondral bone reaction such as eburnation is not present, changes to the joint cannot be categorised as osteoarthritic, and instead may be indicative of age related degeneration of the joint (Rogers *et al.*, 1987: 185). Where skeletal material was examined by the present author, changes to the joint surface were recorded by anatomical location (both skeletal element and joint). Presence of osteophyte formation, surface porosity, and eburnation were recorded. Subchondral bone sclerosis was not considered for the trabecular bone, as radiography is needed in order to fully demonstrate this in where skeletal elements are whole/unbroken (Rogers *et al.*, 1987: 186; Ortner, 2003: 546).

Clinically, osteoarthritis (OA) is diagnosed based on joint pain and reduction of joint space (Ortner, 2003: 545). Skeletal signs include development of osteophytes, destruction/reaction of subchondral bone (e.g. eburnation, sclerosis), erosion/destruction of the joint surface (e.g. pitting), and changes in the contours of the joint Rogers *et al.*, 1987: 185; Ortner, 2003: 545). These skeletal signs are often associated with the later stages of the condition (Rogers *et al.*, 1987: 185; Ortner, 2003: 545). Furthermore, OA may be monoarticular (where only one joint is involved) or polyarticular (where multiple joints are involved; Jurmain, 1999; Orner, 2003: 547).

Typically, OA can be classified as two different types: primary OA, which develops progressively with age as a result of multiple, interplaying factors such as general biomechanical stress and repeated microtrauma ensuing from everyday activity (Ortner, 2003: 546). Secondary OA may develop earlier in life, usually where a joint is abnormal because it has been affected by another pathological condition, e.g. slipped epiphysis, traumatic injury etc. (Altman *et al.*, 1986: 1040; Jurmain, 1999; Ortner, 2003: 547). However, the distinction between these two types is not necessarily this straightforward: alternate classification systems for OA may include all types of traumatic events (both acute trauma and progressive microtrauma) as causing secondary OA (e.g. Altman *et al.*, 1986: 1049), or even discount the primary/secondary types altogether (e.g. Moscowitz, 1993)

"Degenerative joint disease" (DJD) has been used as an alternative term to OA (Bennett *et al.*, 1942; Jurmain, 1999; Salter, 2002). Steckel *et al.* (2006: 31) define DJD as being "created by a number of factors, but mechanical stress associated with physical activity, in combination with a genetic predisposition, is often involved", as well as being influenced by progressive age. The Global History of Health Project describes lesions associated with DJD as including osteophytic lipping at the joint margins, pitting and destruction of the joint surface, and eburnation: these skeletal symptoms are very similar the aforementioned symptoms of OA (Ortner, 2003: 545; Steckel et al, 2006: 31). However, the term DJD has also been critiscised as being ill-defined, with confusion leading to the terms DJD and OA being used both interchangeably and to indicate separate conditions (e.g. Radin *et al.*, 1970; Bellamy, 1985; Dieppe, 1987: 16.76; Jurmain, 1999; Salter, 2002: 11).

Many of the skeletal remains included in the present study could not be examined by the author, and the sources from which data were derived did not always explicitly define the precise criteria by which the presence osteoarthritis (or degenerative joint disease, which was also recorded) had been established. Potential differences in recording strategies and overlapping/differential definitions of OA/DJD meant that for the purposes of this project, all lesions recorded by previous authors as OA and/or DJD were grouped together and are discussed together in the following sections. Data were then subdivided into lesions affecting the vertebrae (spinal joint disease) and all other locations (extra-spinal joint disease): osteological research has shown that anatomical differences between the apophyseal and intervertebral disc joints of the vertebrae and synovial joints elsewhere in the body cause differential degeneration (despite similarities in the skeletal manifestations), hence spinal and extra spinal lesions should be kept separate for the purposes of interpretation (Jurmain, 1999; Ortner, 2003: 547-9; Steckel, 2006: 31-3).

Therefore, when combined with new data recorded by this author for the present study, evidence for spinal joint disease comprises marginal lipping, osteophytosis, degenerative surface changes (e.g. pitting), and eburnation/evidence of sclerosis located on both the vertebral bodies and interarticular facets of cervical, thoracic, lumbar, and the first sacral vertebrae. Evidence for extra-spinal joint disease comprises marginal lipping, osteophytosis, degenerative surface changes (e.g. pitting), and eburnation/evidence of sclerosis on any of the non-vertebral joints. Additionally, Schmorl’s nodes were recorded separately as the precise relationship between development of Schmorl’s nodes and development of spinal joint disease is not precisely understood (Hansson and Roos, 1983; Tribus, 1988; Parrington and Roberts, 1990; Coughlan & Holst, 2000; Knüsel, 2000; Knüsel & Boylston, 2000; Robb *et al.*, 2001; Faccia and Williams, 2008: 30-1; Dar *et al.*, 2010: 675).

Many of the reports and papers containing data for skeletal individuals from York that could not be examined by this author do not discuss the precise criteria by which the presence osteoarthritis has been established. Reports may discuss age-related degenerative joint disease (DJD) and/or osteoarthritis, or only appear to consider one or the other of these pathological conditions. If no specific diagnostic criteria are discussed, it is therefore difficult for the present author to ascertain which condition has in fact been observed. Therefore, because of potential inconsistency in the diagnosis of age-related DJD and osteoarthritis between reports, coupled with the fact that the present author was not able to radiograph available skeletal material for evidence of subchondral bone changes to the trabecular bone, data for osteoarthritis and age-related DJD were combined in the present study. Results and prevalence ranges are presented in Chapter 4 as spinal joint disease, extra-spinal joint disease and Schmorl's nodes. Time constraints and differential recording strategies in collated reports also meant that it was not possible to fully assess the severity of DJD in each individual.

Schmorl's nodes are visible as indentations on the superior or inferior surfaces of vertebral bodies. Schmorl's nodes represent sites of herniation in the intervertebral disc material through the vertebral body end plates (Rogers, 2000: 169-70). They are usually most common in lower thoracic and lumbar vertebrae (Rogers, 2000: 170). They are likely to form as a result of the combination of activity related stresses placed on the vertebrae and intervertebral disc, and developmental factors associated with vertebral formation and growth in early life (Dar *et al.*, 2010: 675).

Although Schmorl's nodes are a pathological marker frequently associated with DJD of the spine, their presence/prevalence has also been associated with levels of physical activity (particularly increased axial loading; Wagner *et al.*, 2000), predisposition to development of these lesions and development of the vertebra during early life (Hansson and Roos, 1983; Tribus, 1988; Parrington and Roberts, 1990; Coughlan & Holst, 2000; Knüsel, 2000; Knüsel & Boylston, 2000; Robb *et al.*, 2001; Faccia and Williams, 2008: 30-1; Dar *et al.*, 2010: 675). For this reason, Schmorl's nodes are considered separately to spinal joint disease in the present study.

Skeletal lesions associated with gout are produced when urate crystals accumulate in the articular cartilage, subsequently ulcerating and destroying the underlying bone (Aufderheide and Rodríguez-Martin, 1998: 108-11). These lesions are most commonly observed in the first metatarsophalangeal joint of the foot, but can also be observed in other joints in the hands and feet (Aufderheide and Rodríguez-Martin, 1998: 100). Gout is more common in males than females, though it is more frequent in post-menopausal women (Rogers, 2000: 172; Nuki and Simkin, 2006). In present day populations the condition is commonly associated with diet, namely excessive consumption of alcohol (Nuki and Simkin, 2006). In Roman populations, an association has been made between gout and lead poisoning (Boulakia, 1972; Nriagu, 1983; Craswell *et al.*, 1984; Hernberg, 2000).

Individuals exhibiting possible evidence of gout could not be examined by the present author. All these individuals were from sites along Driffield Terrace. Osteological archive notes stated that in all of these observed cases, various bones of the feet exhibited lesions that were possibly indicative of gout (Tucker, 2005); descriptions of these lesions were minimal, and so for the purposes of this study, these cases remain unconfirmed.

Four categories of non-specific infection were recorded for this study: periosteal new bone, osteitis, osteomyelitis and miscellaneous non-specific infection. Periosteal new bone (also referred to by many osteologists as “periostitis”) is formed as a response to inflammation of the overlying soft tissue (Grauer, 2012: 493), although its formation may also be a response to other pathological conditions or stress e.g. trauma (Cox and Mays, 2000: 148). Osteitis is used here to describe pathological changes to the bone related to non-specific infection of the bone cortex (Cox and Mays, 2000: 146). Osteomyelitis is used here to describe pathological changes to the bone related to non-specific infection of the bone marrow (Cox and Mays, 2000: 146; Ortner, 2008: 195). The latter, miscellaneous category includes examples from osteological reports where non-specific infection has been noted but not sufficiently described to ascertain which part of the bone structure has been affected.

These forms of non-specific infection can all occur in numerous specific infective pathological conditions such as tuberculosis, syphilis etc. They are also used by osteologists as general indicators of stress (Cox and Mays, 2000: 147). None of the examples included in this section provided sufficient evidence to diagnose a specific infection.

Maxillary sinusitis is “inflammation of the mucous membranes in one or more of the paranasal sinuses” (Roberts, 2007: 795). It can be caused by a variety of factors that irritate the mucosa, including environmental pollution (indoor and outdoor), exposure to dust or smoke, weather, climate, or exposure to mould or fungus just to name a few (Honicky *et al.*, 1985; McCurdy *et al.*, 1996; Howe 1997:31; Bernofsky, 2010: 21-2). Low prevalence of maxillary sinusitis is expected in the York population, as internal analyses of the sinus cavity could not be conducted with an endoscope: recent studies now commonly utilise endoscopes to observe and record maxillary sinusitis (Roberts, 2007: 797). Furthermore, it is unclear how many of the comparative populations were examined for maxillary sinusitis using an endoscope. The results of this section should therefore be regarded cautiously.

Maxillary sinusitis was only observed macroscopically, and unfortunately, without the use of an endoscope. Therefore, only skulls with broken maxilla could be observed for presence/absence of maxillary sinusitis. If the interior of the sinus could not be observed, evidence of maxillary sinusitis could therefore not be recorded. It should be noted that this may have led to under-representation of maxillary sinusitis in this study. Furthermore, these issues make it difficult to compare observed rates of maxillary sinusitis between reports.

Clinical definitions of osteopenia and osteoporosis tend to overlap; in this study osteopenia was used by this author to describe observed loss of bone mineral density without fracture (White and Armelagos, 1997: 185; Ortner, 2003: 410). Osteoporosis also creates reduction in bone mineral density, but the term is usually used to describe individuals with this and associated fractures (White and Armelagos, 1997: 185; Ortner, 2003: 411-5). Osteoporosis was diagnosed in one individual that could not be observed by this author; only report data was available. As this author could not examine this individual, the original diagnosis of osteoporosis was retained.

When recording lesions associated with porotic hyperostosis and cribra orbitalia, the present study utilised recording standards as outlined by Steckel *et al*. (2006: 13). Porotic hyperostosis was deemed as present if slight pitting or porosity through to gross lesions with excessive expansion and exposed diploë were observed on the parietal or other cranial bones. Cribra orbitalia was deemed to be present if slight pitting to severe porosity were observed in the superior orbits. Only macroscopic observation of these lesions was conducted, therefore presence of these lesions is best considered as a general stress indicator (Steckel *et al*., 2006: 13).

Button osteoma are benign primary bone tumours are composed of mature lamellar bone, and are more frequent in males than females (Aufderheide and Rodríguez-Martin, 1998: 375). They are most usually found on the skull, e.g. frontal and parietals, and whilst they are predominantly found on the outer table they can be located on the inner table (Aufderheide and Rodríguez-Martin, 1998: 375; Eshed *et al*., 2002). Osteoma can also be found post-cranially, but less frequently (Aufderheide and Rodríguez-Martin, 1998: 375). As these tumours are benign, they do not impact significantly upon health (Roberts and Cox, 2003: 280).

Osteochondroma is also a benign tumour, which usually develops before the age of 30 years (Aufderheide and Rodríguez-Martin, 1998: 381). Approximately 50% of these tumours are found on the metaphyses of the knee joint (lower femur and upper tibia), with the majority of others located on other long bones (Aufderheide and Rodríguez-Martin, 1998: 381). Osteochondroma, like other tumours, have low frequencies in the archaeological record (Anderson, 2000, Roberts and Cox, 2003).

Neoplastic lesions were recorded descriptively, and assessed as to whether they represented benign or malignant tumours. No malignant tumours were observed by the present author, therefore radiography of bones in order to detect malignant changes to the internal one structure were not necessary.

All bones were scored for presence/absence, and each bone or fragment was examined for the presence/absence of pathological lesions or evidence of pathological conditions. Each skeletal element was scored for presence on a scale of 0 to 1, with 0 denoting absence, 0.5 indicating that up to 50% of the bone was present, and 1 indicating that 50-100% of the bone was present. It should be noted that as many bones were not whole exemplars, missing fragments could potentially express evidence for a pathological condition that did not manifest elsewhere in the element or skeleton. Thus, true and crude pathological prevalence rates produced in this study reflect observed minimum prevalence. The dentition was examined for presence/absence of the teeth and sockets, and each tooth was examined for presence and absence of pathological lesions or conditions (including dental calculus, dental caries, abscess/granuloma, enamel hypoplasia, periodontal disease, ante-mortem tooth loss, and other dental anomalies); locations of any observed pathologies were noted on the appropriate pro forma recording sheet. Calculus, dental caries and enamel hypoplasia were scored for presence/absence per person and per tooth, but not for severity. Prevalence rates of ante-mortem tooth loss were calculated according to the number of tooth positions and the number of these affected. Individuals were only scored for presence or absence of changes in the alveolar bone associated with periodontal disease, and were not scored for severity.

Osteological data from Trentholme Drive compiled by Peck (2011, pers. comm.) was integrated into this study as follows. Long bone and clavicular presence and absence were incorporated into the skeletal inventory as with all other skeletal element data. Elements from the axial skeleton were not included, except where specific bones were mentioned as present in the Peck database notes. Where individuals had a recorded cranial vault score of more than 90%, a score of 1 was given for the parietal, temporal, sphenoid, occipital and frontal bones (see pages 70-7 for a full explanation of the recording strategy in the present project). Where individuals had a cranial vault score of less than 90%, cranial bones were not added to the skeletal inventory as it was impossible to tell which of these bones were incomplete or absent. Minimum maxilla and mandible presence was deduced based on tooth/tooth socket presence and location (e.g. where 32 tooth sockets were recorded it was assumed that both the left and right maxilla and mandible were present). The Peck database only specifically records the presence and absence of the first and second molars; these were added to the tooth inventory for each individual where applicable. In a minority of cases it was possible to deduce whether other teeth were present (e.g. if 32 permanent teeth were recorded as present, all teeth could be added to the inventory). Where tooth status (e.g. present/absent/lost post or ante-mortem) was unknown, the inventory entry was left blank.

Cremation burials were analysed according to the protocol of Brickley & McKinley (2004). Each cremation deposit was weighed to the nearest 0.1g using Scout Pro Balance digital weighing scales. The cremated bone was then sieved into 10mm, 5mm, 2mm and residue sieve fractions. Pyre goods and debris, as well as non-human skeletal elements, were removed and recorded separately (although the data was not utilised as part of this study). Each sieve fraction of human cremated bone was weighed and the maximum dimension of the largest fragment measured to the nearest 0.1mm using 150mm sliding callipers. Identifiable material in each sieve fraction was divided into elements from the skull, axial skeleton, upper limb and lower limb. Where it was not possible to determine whether a fragment belonged to a specific long bone, it was recorded as unidentified limb. Bone in each of these identifiable categories was weighed according to sieve fraction, with total weights for each category also being calculated. Total weight of unidentified bone was also calculated.

Identifiable cremated material was examined for evidence of duplicate elements (indicating number of individuals present). Where possible morphological observations were made pertaining to age and sex, and fragments were also examined for pathological evidence.

For disarticulated bone, numbers of each skeletal element were recorded per context. As far as possible, elements were identified, assigned as left or right side of the body and measured using an osteometric board (if complete long bones). Where determinable, age, sex and pathological evidence were recorded using the methods described above.

Photography of skeletal material was undertaken using one of two cameras. Where material was brought to the Department of Archaeology at the University of Sheffield for osteological assessment, photographs were taken with a digital Canon E0S 20D. Where material was assessed at its storage location, photographs were taken with a digital Olympus µ760. All photographs were edited in Microsoft Office Picture Manager 2006.

Once skeletal material was recorded by the author, data were entered into a number of databases. A basic skeletal database was compiled initially (in Microsoft Excel 2007) to summarise data for each individual (inhumation burial, cremation burial or disarticulated context). This summative database recorded unique record I. D. (e.g. site code), site name, skeleton number, material type (inhumation, cremation or disarticulated), cremation weight (if applicable), completeness (%), preservation, age, sex, stature, non-dental and dental pathology. Dental and skeletal inventories were compiled with data from pro forma recording forms being added to a second digital database (also in Microsoft Excel 2007).

Skeletal inventories were divided into inhumation burials, cremation burials and disarticulated material. For each inhumation burial, skeletal part representation was recorded. Each skeletal element was scored on a scale of 0 to 1, with 0 denoting absence, 0.5 indicating that up to 50% of the bone was present, and 1 indicating that 50-100% of the bone was present. For each cremation burial, total weight of human bone as well as sieve fraction weights, skeletal element weights, weights of identified and unidentified bone were recorded. Once the total weight of human cremated bone was calculated (by adding together the total amount of human bone in each sieve fraction), the percentage of the overall cremation deposit present in each of the sieve fractions was calculated. Disarticulated material was recorded per context, with the quantity of each identified element, unidentified long bone, unidentified fragments and burnt fragments recorded. Where skeletal fragments were identifiable they were recorded as a minimum number. For example, four broken rib shaft fragments were recorded as a minimum of one rib. Unidentifiable fragments were recorded in terms of number of fragments present.

A dental inventory was compiled for each dentate individual and also for teeth found in cremation burials or disarticulated contexts. Each tooth was scored according to the key given in Table 3.3.

Symbol	**Description**
P	Present
\	Lost post mortem
X	Lost ante mortem
#	Tooth present, socket absent
NP	Not Present
B	Broken
E	Erupting
U	Unerupted

Table 3.3: Dental scoring key

The methodology outlined above applies to all skeletal material examined by the author for this study. However, as previously discussed (page 63-4), a large corpus of data was compiled from published and unpublished osteological reports. The majority of data produced by other authors (and collated for this study) were gained using standard osteological methods, as outlined in the BABAO *Guidelines to the Standards for Recording Human Remains* (Brickley and McKinley, 2004). While some osteological reports (those pre-dating publication of the BABAO 2004 standards) do not necessarily conform to these exact recording standards, in many cases the same recording and/or analytical methods were in fact used to produce data. Collated data were entered into the aforementioned databases as far as possible. In many instances, skeletal element presence/absence, demographic data and dental/non-dental pathological data was readily available. However in some cases dental and non-dental inventory data was not provided or recorded differently from the methods outlined for this study.

For sites where data were taken from a report and a full inventory was not available, the presence or absence of skeletal elements was assessed by this author on the basis of skeletal descriptions, photographs and archaeological drawings. Bones were not included in the inventory for this study if they were not included in the original skeletal inventory, skeleton description, or could not be observed in photographs or drawings. For small bones that may not easily be observed in photographs or drawings such as the hands and feet, where it was apparent that some bones were present but the exact quantity or individual bones could not be identified, minimal bone numbers were added to the database, e.g. one tarsal and metatarsal per foot. Where a number of phalanges present were given but the bones not assigned to the left or right side, bones were distributed as evenly as possible between left and right.

As discussed above, the adoption of data from the Trentholme Drive assemblage was particularly problematic, thus information was derived from a number of sources. The Wenham (1968: 129-145) skeletal remains catalogue was used in calculating minimum number of individuals present in the assemblage. For other demographic analysis, age, sex and stature data was taken from Peck (2009) and individuals analysed by the author from the Yorkshire Museum.

Data from comparative Roman urban sites (listed in Table 3.2) was collected from published reports. As far as possible data on minimum number of individuals, age at death, sex, stature and dental/non-dental pathological prevalence was collected from each site report. Analytical methods are discussed below.

3.3.2. Demography

The discipline of demography addresses the composition of human populations, more specifically their size, structure and development (Bagnall and Frier, 1994: 31). Sources of data with which to conduct demographic analysis in archaeology are wide-ranging. Analysis can incorporate proxy data from areas of settlements or quantities of artefacts, historical or ethnographic sources such as census data or parish burial registers or, in the case of palaeodemography, human skeletal remains (Hassan, 1978: 51; Bagnall and Frier, 1994). This study aims to use data from human skeletal remains to address research questions relating to the size and composition of the population of Roman York.

It is important to distinguish at this point the difference between stationary and stable populations: stationary populations have identical birth and death rates and hence a growth rate of zero; stable populations have differential but constant birth and death rates, therefore meaning that a population will either be in growth or decline (Bagnall and Frier, 1994; 79). As living populations rarely remain stationary, it is also necessary to address factors that may facilitate population change such as changes in mortality and fertility rates and also the effects of migration. There are a number of problems in palaeodemographic studies regarding bias. Representational bias may be present in a sample of archaeological human skeletal remains as a result of factors such as skeletal preservation, taphonomy, excavation strategy, and the much discussed under-representation of sub-adults (for the purposes of this study, subadults are classified as individuals aged under 15 years) to name but a few.

Methodological bias may be introduced as a result of inaccuracies in aging and sexing methods utilised during analysis. The population itself may also be biased as a result of migration or other factors, e.g. burial of a population sub-set. For example in the Roman period, representative numbers neonates and infants are seldom found at urban cemetery sites, but are often found in association with buildings (Esmonde Cleary, 2000: 135). A number of rural and villa sites (e.g. Hambleden, Barton Court Farm, Bradley Hill) have also been found to have significantly higher proportions of infant burials, although it has recently been postulated that this may be the result of infanticide (Esmonde Cleary, 2000: 135; Mays, 2011). This study aims to counteract problems of osteological bias by using multiple aging and sexing methods where possible (discussed on pages 71-2). Interpretation of data will therefore take into account any inherent sample bias caused by the aforementioned factors.

Demographic analysis in this study is focused on sex distribution and age distribution, and stature (stable isotope and morphometric data relating to migration and population affinities is only available for a small part of the York assemblages; Leach *et al.*, 2009). Although stature is not typically considered a demographic variable (being more related to health and diet) it is partially influenced by population affinities and was therefore included in the demographic section of this thesis. Demographic data gleaned from the archaeological sample of human skeletal remains was then used to estimate the size and average lifespan (i.e. the average number of years that an individual could be expected to survive) of the Romano-British population of York.

Once sex estimations were made, absolute numbers were calculated of males, females, individuals of indeterminate sex and individuals of unknown sex. Data were tabulated and plotted in a bar graph in Microsoft Excel 2007, and sex ratios were calculated (number of female individuals per single male individual). The same process was undertaken for the comparative assemblages in order to facilitate direct comparison of sex ratios between populations.

Once age estimations were made, the mean age was calculated for each individual skeleton. Individuals were then divided into the following age categories according to their mean age; 0-4 years, 5-9 years, 10-14 years, 15-19 years, 20-24 years, 25-34 years, 35-49 years and over 50 years. The age categories reflect the precision with which age at death can be estimated from the skeleton, with five-year age categories being employed to 24 years, and three broader age categories for adults aged 25 years and over. For the purpose of demographic analysis, individuals that could not be aged any further than “adult” or “sub-adult” were then aggregated into the aged sample. This method assumes the age structure of the unaged individuals is the same as that of the aged sample, redistributing the unaged individuals between the appropriate age categories proportionate to the number of aged individuals already placed in that category. Aggregation therefore boosts the sample size in each given age category, contributing proportionally to the number of deceased adults and sub-adults. Aggregation is necessary to enlarge the sample size appropriately: this is especially important with the sub-adult age categories, where low archaeological recovery rates have caused sample sizes to be low. Individuals of unknown age were not aggregated, as the aggregation of individuals of unknown age would only affect the total number of individuals used in the analysis, not the proportions of adults and sub-adults present.

The following formula (where N equals the total number of individuals to be aggregated in to a known age category, (a) equals the number of individuals aged no further than “adult” or “sub-adult”, (b) equals the number of individuals already placed in the relevant age category, and (c) equals the total number of adults or sub-adults) was utilised to aggregate individuals aged as “adult” or “sub-adult” into the analysis.

$$N = \left(\frac{ab}{c}\right)$$

The following example demonstrates how these calculations are used in this study. At the East London cemetery assemblage 381 individuals (inhumations) out of a possible 550 were assigned age at death estimations (Barber and Bowsher, 2000: 417-27). Of the remaining 169 individuals, seventeen were classified as “sub-adult”, 117 as “adult”, and 35 as “unknown”. For the purpose of this aggregation, “sub-adults” are aggregated between the 0-4yr, 5-9yr, 10-14yr and 15-19yr age categories. “Adults” are aggregated between the 20-24yr, 25-34yr, 35-49yr, and >50yr age categories.

Sub-adults of known age were distributed as shown in Table 3.4.

Known Sub-adult Age Categories	**No. Individuals Known Age**
0-4 yrs	41
5-9 yrs	27
10-14 yrs	25
15-19 yrs	27
Total	**120**

Table 3.4: Number of sub-adults per age category, East London Cemetery (Barber and Bowsher, 2000: 279)

Using the 0-4 year age category as an example, sub-adults of unknown age were aggregated (to two decimal places) as follows; (17 x 41) / 120 = 5.81.

Therefore, 5.81 individuals can be added to the total number of sub-adults in the 0-4yr category. Using the same equation, the rest of the “sub-adults” of unknown age are aggregated between categories as seen in Table 3.5.

Known Sub-adult Age Categories	No. Individuals Known Age	No. Aggregated Individuals
0-4 yrs	41	5.81
5-9 yrs	27	3.83
10-14 yrs	25	3.54
15-19 yrs	27	3.83
Total	**120**	**17**

Table 3.5: Number of aggregated sub-adults per age category, East London Cemetery (Barber and Bowsher, 2000: 417-27)

The same method, when applied to figures for “adults” of unknown age produced the results seen in Table 3.6.

Known Adult Age Categories	No. Individuals Known Age	No. Aggregated Individuals
20-24yrs	40	17.93
25-34yrs	88	39.45
35-49yrs	124	55.59
>50yrs	9	4.03
Total	**261**	**117**

Table 3.6: Number of aggregated adults per age category, East London Cemetery (Barber and Bowsher, 2000: 417-27)

Now that all individuals have been aggregated, the aggregated results for individuals of unknown age can be added to the number of individuals of known age to get the total number of individuals in each age category, as seen in Table 3.7. Totals in each age category are rounded to the nearest whole number.

Age Categories	Total No. Individuals
0-4 yrs	47
5-9 yrs	31
10-14 yrs	29
15-19 yrs	31
20-24yrs	58
25-34yrs	127
35-49yrs	180
>50yrs	13
Total	**515**

Table 3.7: Total number of individuals, East London Cemetery (Barber and Bowsher, 2000: 417-27)

Age at death distribution was calculated by tabulating the number of individuals in each of the age categories indicated above and plotting these data in a bar graph in Microsoft Excel 2007. Life tables for York and each comparative site were constructed in order to calculate mortality profiles and expectation of life for each age category. There are two main types of life table. Firstly, instantaneous life tables (also known as static life tables) determine the effects of age specific mortality on a hypothetical cohort of individuals (Shryock *et al*., 1980: 535; Chamberlain, 2006: 28; Vallin and Caselli, 2006a: 163). Secondly, cohort life tables (also known as generation life tables; Schryock *et al*., 1980: 429) incorporate data for a known group of individuals born at the same time, and mortality needs to be monitored over at least one maximum lifespan (Chamberlain, 2006: 28; Vallin and Caselli, 2006b: 103). Cohort life tables are more applicable to living populations, where demographers have access to data that allows selection of the correct number of individuals all born within a short time span. As it is not possible to do this with archaeological populations, instantaneous life tables were constructed in the present study.

Mortality profiles show the percentage of the population that died in each age category (Bagnall and Frier, 1994: 35). Expectation of life values allow observation of average life expectancy for each age category under the same mortality conditions (Bagnall and Frier, 1994: 35). These analyses allow comparisons to be made between different populations effectively where sample sizes may differ.

Data from comparative assemblages were adjusted proportionally to fit the age categories selected for this study, in order to facilitate direct comparison of age ranges between populations. This adjustment was made by assuming individuals were evenly distributed within each designated age category. Data from “West” female model distributions (constructed using late nineteenth to mid-twentieth century mortality data for females from Australia, Belgium, Canada, Denmark, Britain, Estonia, Finland, France, Ireland, Israel, Japan, Latvia, Luxemburg, the Netherlands, New Zealand, Sweden, Taiwan, South Africa and the United States) for populations with an average age at death of 20 (Level 1) and 30 (Level 5) years were also utilised (Coale and Demeny, 1983: 12) to facilitate comparison with predicted patterns of mortality; Bagnall and Frier, (1994: 1 and 109-10) suggest that the average life expectancy at birth in Egypt during the Roman period was approximately 20 to 30 years, based on demographic research and statistical analysis of demographic data from census returns dating to the first to third centuries A.D. Average adult life expectancy is usually higher than life expectancy at birth as it excludes the effects of high infant mortality rates; for example estimations of Romano-British average adult age at death were calculated at 34.8 years for males and 31.9 years for females when utilising data from individuals aged 19 years and over (Brothwell, 1972: 83). Mortality profiles were also calculated for males and females in order to ascertain whether there were any differences in age at death profiles between the sexes.

Bias in osteological aging methods can potentially cause problems with palaeodemographic analyses; osteological aging methods such as the ones discussed above have been known to consistently over age adult individuals (less than 45 years of age) and under age older adults (over 50 years of age; O'Connell, 2004: 19). This is exacerbated by the use of broad age categories and the distribution of individuals according to their mean age. These problems can lead to an unrepresentative mortality peak in the mid adult age bracket: a high number of deaths appear to occur in the mid adult age bracket as a consequence of each broad estimated age range being reduced to a mean value. To counteract this, data from the York assemblage were smoothed by redistributing the age of each individual across the given age ranges.

Individuals were redistributed according to the probability of where the individual actually lies within the age range of the assigned auricular surface or pubic symphysis score. For example, in the Lovejoy *et al*. (1985) method of age estimation using the auricular surface of the pelvis, an auricular surface score of "4" equates to an age range of 35-39 years, therefore placing the mean age at death at 37 years (Lovejoy *et al*., 1985: 27). However, the five-year age interval equated with a score of 4 only represents the modal age estimation associated with that score (Lovejoy *et al*., 1985: 21). Each assigned age score also has an associated degree of error (a number of years either side of the modal age range in which the actual age at death of the observed individual may realistically fall), and also bias (whether the age at death of the observed individual is more likely to be over or under estimated; Lovejoy *et al*., 1985: 7). Rather than assuming that the observed individual does fall within the modal age range, it is more appropriate to assume that the age at death actually lies at any point across the total age range, incorporating the error margins and degree of bias (Konigsberg and Frankenberg, 1992; Chamberlain, 2006: 114). Application of Bayesian statistical modelling to skeletally determined age at death estimates calculates the probability of an individual being of any of the given ages across the entire age range, rather than simply utilising the mean age at death (Konigsberg and Frankenberg, 1992; Chamberlain, 2006: 114). This method therefore offsets methodological mortality bias, as it prevents mortality artificially clustering around common mean ages and compensates for over or under aging of certain groups of adults.

Auricular surface and pubic symphysis scores were not available for the majority of individuals, as skeletal reports rarely include the vast quantities of raw data compiled during the analysis of each individual. Therefore, auricular surface scores (ranging from one to eight; Lovejoy *et al*., 1985) were taken only where possible: from 45 individuals examined by this author, and the skeleton sheets of 10 individuals from the Blossom Street assemblage (1989/90.21; York Archaeological Trust, 1990). Pubic symphysis scores (ranging from one to six; Brookes and Suchey, 1990) were taken from 22 individuals examined by this author, and the skeleton sheets of seven individuals from the Blossom Street assemblage (1989/90.21; York Archaeological Trust, 1990). The number of individuals assigned to each auricular surface or pubic symphysis score were counted, and then were subjected to appropriate Bayesian calculations, after Gowland and Chamberlain (2005; Chamberlain, pers. comm.). All individuals in the two samples were therefore redistributed across the relevant age ranges as described in the previous paragraph. These results were then re-adjusted across the author's original age categories so that the smoothed data could be compared with the raw and model data. This method was also applied to the auricular surface scores for 32 males and 20 females from the above sample, and in order to produce smoothed data according to age *and* sex.

Stature was calculated separately for males, females and individuals of indeterminate sex. Once stature estimations were made for each skeleton, these were averaged. Data were tabulated and plotted as box and whisker plots in Microsoft Excel 2007 in order to allow observation of mean stature and stature range for each sex. The same process was undertaken for the comparative assemblages in order to facilitate direct comparison of stature means and ranges between populations.

Few attempts at estimating the size of the population of Roman York have been made. Warwick's estimations (in Wenham, 1968: 148) based on skeletal evidence from Trentholme Drive placed the average population at 2,000-3,000 individuals, with a death rate of 50-75 per year. This estimation is based on hypothetical population size estimates where average life span is placed at 40 years, and the assumption that the total cemetery area round York was approximately ten times the (then) total excavated area at Trentholme Drive, containing no more than 10-15,000 individuals (Wenham, 1968: 148). Jones (1984: 41) postulates a higher figure, estimating that the initial military population responsible for establishment of the fortress must have numbered somewhere between 5,000 and 6,000 men, with an average overall population of 4,000 to 6,000 individuals over the three centuries that the site was occupied. This estimation amends Warwick's figures to take into account more recent excavation data, as well as the assumption that the Trentholme Drive excavation accounted for a much smaller proportion of the total area in York used for burial (putting the total expected number of dead at 30-45,000; Jones, 1984: 41). Addyman (1989: 246) agrees with this estimation of an initial population of approximately 5,600 military personnel. Although Addyman (1989: 246) does not explicitly state where this figure is taken from, it is likely to be based on a statement made by Suetonius (translated by Reifferscheid and Ritschl, 1860: 278) in a written fragment of unknown date, where he refers to there being 5,600 men in one legion in residence, at least in the first century A. D. and presumably prior to the forming of the civilian settlement at *Eboracum*. Ottaway (2004: 128) states it would be unlikely that the civilian settlement would comprise more than 3,000 individuals (based on the size of the settlement and likely population density), thus the total (military plus civilian) population of York would be in the range 7,000-10,000.

Estimations made for other Romano-British urban settlements are equally imprecise. Wacher (1974: 48) estimated the population of Roman Leicester (*Ratae Coritanorum*) at 3,000-4,000, although it is unclear what information this estimation is based on. Potter (1992: 68) estimates that larger urban settlements such as Cirencester, Colchester and St. Albans may have had average populations of approximately 15,000, with smaller principal towns having populations between 3,000 and 5,000 people. These estimations appear to have been made to consider the size of Romano-British populations proportionally to those of larger towns elsewhere in the Empire, such as *Caesarea Mauretanensis*, located in modern day Algeria/Morocco, where more demographic information is available. Similarly, Frere (1992: 256) proposes a starting population of around 15,000 for Colchester, with smaller settlements such as Lincoln and Gloucester approximating an average population of 5,000 and minor settlements such as Silchester typically having a population of 2,500 to 4,000 people (with this estimation being based on the size of the known Roman town). Ottaway (2004: 128) suggests that the civilian population of London may have peaked at approximately 10,000 individuals, again, an estimation largely based on the maximum size of the town. The overall living population of Roman Britain has recently been estimated as peaking at 2 million people, based loosely on predicted numbers of local councillors and expected number of individuals in various social classes (Mattingly, 2007: 293). It should be noted that all these are estimates are extremely crude, particularly because they do not take into account population growth, fluctuation or decline.

This study aims to re-estimate the size of the population of Roman York. Population size can be estimated based on the overall size of a settlement, but this is difficult in the case of urban sites where there is a large range of inter-regional variation in the spatial density of human settlement (Chamberlain, 2006: 127-8). Problems often arise in palaeodemography, not least because the burial population is likely to represent an unknown proportion of the living population (Schacht, 1981: 121-2). It is also necessary to determine the period of cemetery use in order to estimate the overall size of the parent population (Schacht, 1981: 121-2). In this study, population size was estimated using two independent methods in order to observe whether consistent results could be produced.

Firstly, average population size (P) was calculated according to Acsádi and Nemeskéri (1970), using data from life tables constructed for this study in conjunction with burial data. Average population size is calculated by multiplying life expectancy at birth (e, as taken from life tables constructed in this study) by the total number of dead (d) over the total time period that burial is taking place (t):

$$P = \left(\frac{ed}{t}\right)$$

In order to calculate the total number of dead, burial density had to be established. Burial density was calculated using the excavated burial location data utilised for spatial density analysis in this study. In the spatial density analysis (see pages 98-9 for methodology), three main cemetery regions were defined around *Eboracum*: the south west cemetery; the north west cemetery; and the south east cemetery. As these are only approximate cemetery areas based on known burial locations, three further “peripheral” regions were defined outside each of these main cemeteries: the south east peripheral area; north west peripheral area; and south east peripheral area. These three peripheral regions represent locations where burials have been found but in lower density/frequency than in the main cemetery areas. Three separate peripheral regions were created to take into account differences in burial density across the area. The three peripheral cemetery areas are not considered to represent a specific marked or bounded area, but represent liminal and/or less desirable interment sites away from the main roads. The last remaining part of the study area was defined as the “outlying” area, where isolated burials have been found. Once these areas were defined, the approximate size of each was determined in ArcGIS 9.3.

Only sites with known excavation area size were used. The Railway Cemetery was not included here, as the majority of individuals excavated at this site were not recorded. Burial density (per m^2) was calculated for each region by dividing total number of burials by the excavated area. The only exception to this was the north west peripheral region, where excavated area was unknown. Burial density in the north west peripheral region was therefore established by calculating average burial density of the south west and south east peripheral regions.

Once the overall burial density was established, the expected number of dead was calculated for each region by multiplying the total region area by the appropriate burial density. Expected number of dead was also calculated for the Railway Station site, by multiplying the excavated area (167,809m^2) by the calculated burial density for the south west cemetery. The expected number of dead for each region could then be added together to give the total number of dead for the full period of Romano-British occupation of *Eboracum*.

Number of known deaths per year (D) was calculated by dividing the total number of dead (d) by the total time period that burial is taking place (t):

$$D = \frac{d}{t}$$

Note that to convert this into a reliable estimate of the total living population one needs to estimate the proportion of the total number of deaths that have been recovered through excavations of Roman period cemeteries (see spatial density analysis section below).

Secondly, population size was estimated based on the size of the settlement of *Eboracum*. This method assumes that a linear relationship exists between population size and settlement size (Wiessner, 1974). This technique estimates population (P) based on methods proposed by Wiessner (1974), where constant (a) is multiplied by the settlement area (b; measured in hectares):

$$P = ab$$

In this equation, the constant represents the population density (i.e. number of people occupying the settlement per hectare) (Chamberlain, 2006: 128). No single constant can be employed for all scenarios, as different settlement types have different spatial and habitation density and there is much scope for inter-regional and temporal variation (Kramer, 1982: 163). For this study, the constant of 127 persons per hectare will be utilised, based on Richardson's (2000) demographic study of population size in Roman military camps. This is also very close to the constant modal value of 130 persons per hectare calculated by Storey (1997) for pre-industrial urban centres. This study constructed of digitised archaeological maps of Pompeii and Ostia, which allowed plotting of specific known, functionally distinct buildings, plus best reconstruction of unexcavated areas (Storey, 19976). The number of nucleated family units and associated individuals e.g. retainers, slaves populating each settlement were then estimated based on the approximated town layout, size and function (Storey, 1997).

In order to calculate population size in York according to settlement size, the *canabae* and *colonia* were plotted onto a 1: 50,000 scale raster Ordnance Survey map (map tiles SE 44 and 64), which was downloaded from OS Open data (Ordnance Survey, 2011) in ArcGIS 9.3. The fortress had previously been plotted on this map during establishment of the study area. All three features were plotted according to archaeological evidence regarding their size and location. According to Ottaway (2004: 34), the expected dimensions of the fortress at *Eboracum* are approximately1600 x 1360pM (*pes Monetalis*, a "Roman foot", 1pM is equivalent to 0.296m), which equates to approximately 473.6 x 402.56m. This estimated size is based on a fortress floor plan of a size that would accommodate an appropriate number of men and equipment, whilst being of dimensions that could be easily be used to calculate and lay out right angles for the fortress corners, as well as successfully being laid out by soldiers who were potentially inexperienced at surveying using the available survey tools (Ottaway, 2004: 34-5). The area of the fortress as plotted for this study measured 480 x 405m (these measurements are based on direct, *in situ* archaeological evidence for the fortress structure), which is exceedingly close to the expected measurements proposed by Ottaway (2004: 34). The overall area size of the fortress (194,400m^2) is also close to the typical legionary fortress area of 20 hectares (200,000m^2) found elsewhere in Roman Britain (Mattingly, 2007: 132; Wilson, 2011: 2).

Population size and population growth can also be estimated using site catchment analysis and resource utilisation analysis (Dennell, 1980; Chamberlain, 2006: 128). These methods are difficult to convert into absolute population size estimates, partly because it is very hard to estimate the numbers of people that would exist in relation to given amount of material remains (Chamberlain, 2006: 129). Therefore, these methods are more appropriate for estimating relative population size and proportional population growth (see e.g. Marsden & West, 1992 for estimates of population growth in Roman London). In site catchment analysis, the spatial area utilised by a settlement is analysed in terms of economic potential; the quantity and character of resources available to a community allows calculation of the maximum population that can be sustained by said resources (Dennell, 1980; Chamberlain, 2006: 128-9). This model is more suited to hunter-gatherer communities, as each community functions in relative isolation compared to later agricultural or urban settlements (Dennell, 1980: 7-8). Alternatively, resource utilisation methods use proxies for population size such as number of wells (indicative of demand for water supply), number and volume of storage or rubbish pits, quantities of food residues such as animal bones, number and volume of dateable ceramic types and quantity of building materials to estimate population size and growth (Hassan, 1981; Schact, 1981; Marsden and West, 1992). However, the accuracy of these estimations depends on factors such as the percentage of the settlement subject to excavation (i.e. has a significantly representative sample of the settlement undergone excavation?) and discard/survival patterns for each material type (Chamberlain, 2006: 130). Although sufficient data of this type may be available for Roman York, the aforementioned factors coupled with the amount of time required to source accurate resource usage data with which to make precise estimations in population size and growth mean that these methods are beyond the scope of this study.

As well as the demographic considerations, all sites within the study area were subjected to spatial density analysis. As is discussed in Chapter 4, burials have been found on almost all sides of Roman York and are concentrated around the main roads to the west and south west of the city (RCHME, 1962; Jones, 1984: 35; Ottaway, 2004: 122). However, it is currently unknown whether these areas comprise a number of discrete cemeteries or whether they represent only the excavated parts of one large cemetery, perhaps containing distinct or zoned areas (Jones, 1984: 35). This study aims to clarify this issue, as well as estimate the proportion of cemetery areas that are yet to undergo archaeological intervention, based on known cemetery boundaries and total excavated area.

As stated on page 59, the total size of the study area is 78.54km^2 (78,540,000m^2). In order to calculate burial density, the total minimum excavated area containing burials was calculated. Excavated area was calculated for all archaeological sites utilised in this study (i.e. known archaeological sites yielding Roman burials). Where the excavated area of a site was not known (e.g. where there are no documentary records or site archive), a minimum excavated area of 1m^2 was assigned. The total minimum excavated area was therefore calculated at 182,685.725m^2 (0.183km^2). The total minimum excavated area therefore comprised 0.23% of the total study area. Archaeological sites yielding Roman burials (utilised in this study) were plotted on a map of *Eboracum* in ArcGIS 9.3, in order to illustrate burial density and location. The fortress, *canabae* and *colonia* were plotted in ArcGIS. The known Roman roads entering and leaving *Eboracum* were also plotted, based on archaeological evidence (Ottaway, 2004: 12).

All sites for this study were plotted on the map of *Eboracum* in order to observe the spatial extent of cemetery areas in ArcGIS 9.3. Burials were plotted with markers sized proportionally according to the number of individuals found at each site, in order to ascertain the most densely populated burial areas and therefore demonstrate which burial areas were the most popular. Secondly, burial locations were plotted according to the type of skeletal evidence found (i.e. unburnt inhumation burial, cremation burial or unburnt disarticulated remains). Burials recorded by the 1962 Royal Commission report were then included. Plotting by burial type again indicates the location of preferred burial areas, as well as showing any discernible areas of zoning according to burial rite. Polygons were drawn around the main clusters of burials to encapsulate observed core burial areas. Excavated sites located outside the core burial areas are either outlying (i.e. located away from the main burial clusters), have fewer burials, or have very low burial density.

In order to test the burial evidence for cemetery location preference, find spot locations for tombstones and coffins from the Royal Commission on Historical Monuments (1962) were plotted on the map of *Eboracum* and the three cemetery regions in ArcGIS 9.3. Although the approximate locations of such finds have previously been discussed in the secondary literature (e.g. a stone coffin from Holgate Villa discussed the Yorkshire Archaeological Journal; Wenham, 1960), the precise locations have never been plotted and analysed in this way. As discussed in Chapter 2, burials with associated stone coffins and tombstones have been associated with wealthier members of society, who could afford to be buried in more preferential burial areas. If the aforementioned theory regarding preferential burial spots is correct, it would be expected that the majority of stone markers and coffins would fall within the proposed core burial area. Only tombstones and coffins found in their (presumed) original place of deposition were included, e.g. any found incorporated into later structures, such as the tombstone fragment found built into an eighteenth-century wall at St. Lawrence's churchyard, were excluded as they were not found *in situ*.

3.3.3. Diet

Dental calculus is mineralised plaque situated on the surface of the teeth. Calculus formation has a complex aetiology where diet, levels of calcium and phosphate in the blood, fluid consumption, oral environment, bacterial composition, non-dietary chewing, using teeth as tools, and oral hygiene practices can all be contributory factors (Roberts and Manchester, 1995: 55; Hillson, 1996: 259; Lieverse, 1999: 224-5; Jepsen *et al.*, 2011: 169; Yuan Lai, 2012: 54). Dental calculus forms as a result of dental plaque deposits becoming mineralised; formation of plaque deposits is often exacerbated by poor oral hygiene (i.e. not cleaning the plaque from the teeth: Hillson, 2005: 288-9).

Calculus presence has often been related to diets that are high in protein (Hillson, 1979: 150) or (to a lesser extent) high in fat (Lieverse, 1999: 224). Diets that are rich in protein (and fat) are more likely to produce an alkaline oral environment, or increase alkalinity: as dental calculus formation is exacerbated in this type of oral environment, consumption of foods that are rich in protein (and fat) are therefore condusive to the formation of dental calculus (Hillson, 1979: 150; Lieverse, 1999: 119). Little research has been conducted on dietary composition and calculus prevalence in humans, although studies using animals (e.g. rats; Baer and White, 1966) have suggested that diets high in protein, carbohydrates and fat are conducive to calculus formation (Lieverse, 1999: 224). It has also been suggested that the colour of dental calculus may also be dietary in origin (Hillson, 2005: 290). Whilst a comprehensive review of the aetiology of dental calculus is beyond the scope of this study, the author acknowledges that the anthropological literature has a tendency to oversimplify the relationship between the prevalence and severity of calculus and diet. Therefore caution will be used in exploring the potential information concerning diet that can be derived from study of calculus.

Enamel hypoplasia is a defect in the depth of tooth enamel formation resulting from growth disturbance severe enough to disrupt tooth development during early life (Goodman and Rose, 1990: 61; Ogden, 2008: 284). The hypoplastic lesions can take several forms, ranging from the classic furrow-type defects (linear enamel hypoplasia) to pit-type defects of various sizes, as well as plane-type defects (Goodman and Rose, 1990: 64; Hillson, 1996: 166-7). These non-fatal incidents can represent a variety of causes, but have to be sufficient for the body to divert energy from non-vital processes to those necessary for survival (Aufderheide and Rodríguez-Martin, 1998: 405). Possible causes of enamel hypoplastic defects can include nutritional deficiency and stress, episodes of disease, and a multitude of factors associated with weaning (El-Najjar *et al.*, 1978; Goodman and Rose, 1990; Katzenberg *et al.*, 1996; Dobney and Ervynck, 2000). Although general undernutrition and the resulting physical stress is most the most frequently cited cause of hypoplastic lesions in clinical literature (Moynihan, 2003: 9), studies have also suggested that individuals deficient in vitamin A, vitamin D and protein are more likely to develop hypoplastic lesions (Moynihan, 2003: 9-10; Holick, 2006; Moynihan, 2012: 100). Severe Vitamin A deficiency can impede development of the tooth germ, has also been shown to disrupt formation of both dentine and enamel, and can also cause gingivitis (Schuurs, 2012: 61). Vitamin D deficiency has been shown to cause delayed tooth development, and individuals with insufficient Vitamin D intake have been shown to develop weaker tooth structures (than individuals with sufficient intake of

Vitamin D) as a result of impaired tooth calcification (Moynihan, 2003: 9-10; Schuurs, 2012: 58).

It is likely that interplay between dietary and non-dietary factors (to various degrees depending on each individual case) cause enamel hypoplasia. For the purposes of this study, enamel hypoplasia prevalence will be considered in relation to diet, and whether this and associated evidence suggests the population of Roman York had a diet that was nutritionally sufficient during early life.

Dental caries are caused by bacterial decay, with subsequent destruction of the tooth enamel and dentine leading to formation of cavities in the tooth crown (Liebe-Harkort *et al.*, 2010: 525). Bacteria in dental plaque produce acid in response to carbohydrates, sugars and starch (Hillson, 1979: 150; Freeth, 2000: 229, and Liebe-Harkort *et al.*, 2009: 525). Foodstuffs high in sugar and starch are therefore highly cariogenic, and high prevalence could indicate a diet rich in these foods (Navia, 1994; Hillson, 1996: 278). Clinical studies have suggested that the type, quantity, and intake pattern of these foodstuffs also has a significant effect on the relationship between diet and dental caries (Zero *et al.*, 2008: 330).

Diet is not the only factor likely to affect the prevalence of dental caries in a population. Other factors can include enamel composition and structure, tooth morphology and position, presence and amount of saliva, composition of the diet, and presence of naturally occurring fluorine in drinking water (Soames and Southam, 1985: 19). For the purposes of this study, dental caries will be discussed in relation to diet, as many of the other potentially contributory factors listed cannot be measured in archaeological remains, or cannot be measured without extremely in depth, microscopic analysis that would compromise the time frame set for this project.

Ante-mortem tooth loss is usually the end result of other (progressive) dental conditions, e.g. dental trauma, periodontal disease, or dental wear (Soames and Southam, 1985: 31). Ante-mortem tooth loss can also be the result of decay from progressive dental caries. Therefore ante-mortem tooth loss (along with periodontal disease and periapical cavities) could be used as a proxy to indicate general levels of oral hygiene and health in a population. When compared to rates of dental calculus, enamel hypoplasia and caries, it may be possible to assess the extent to which prevalence of the latter three conditions is affected by oral hygiene and health, i.e. if oral health is generally good but calculus levels are high, this may indicate that calculus levels are more likely to be the result of other factors.

Edentulous individuals are more likely to change their diet so that the amount of raw fruit and vegetables is reduced, as is food containing fibre (Hung *et al.*, 2003; Moynihan, 2012: 99). These changes are likely to be detrimental in terms of nutrition and overall health, and increased consumption of other foodstuffs to replace those being reduced may exacerbate any problems associated with oral or systemic health (Hung *et al.,* 2003). It is therefore possible that past archaeological populations with high prevalence of ante-mortem tooth loss would be less likely to eat raw foods such as fruit and vegetables, which in turn may lead to nutrient deficiency. For this study, ante-mortem tooth loss will be considered in relation to overall dental health and discussed in terms of implications regarding levels of observed tooth loss and possible dietary change.

The term “periapical cavities” describes a number of conditions related to infection of the alveolar tissues. This may include granuloma, abscess, fistula and cysts (Hillson, 1996: 284-7; Dias and Tayles, 1997). These conditions are likely to occur as a result of bacteria entering the root cavity or when the tooth pulp is exposed to bacteria as a result of trauma, heavy occlusal wear or caries (Hillson, 1996: 285). Only cavities visible in the dental arcade were counted; no radiography was performed to detect concealed periapical voids. Periapical cavities are not generally used as dietary indicators. For this study, prevalence of periapical cavities was examined in order to indicate general levels of oral hygiene and health in a population. As with ante-mortem tooth loss and periodontal disease, when compared to rates of dental calculus, enamel hypoplasia and caries, it may be possible to assess the extent to which prevalence of the latter three conditions is affected by oral hygiene and health, i.e. if oral health is generally good but calculus levels are high, this may indicate that calculus levels are more likely to be the result of other factors.

Periodontal disease, or periodontitis, is an inflammatory process affecting the periodontium, whereby the gums and alveolar bone become reduced in height, exposing the root surfaces of the teeth (Roberts and Manchester, 1995: 56-7; Aufderheide and Rodríguez-Martin, 1998: 400-1; Nishida *et al.*, 2000: 1057; Ogden, 2008: 288-9). Periodontal disease may occur in both children and adults, and may result in ante-mortem tooth loss (Soames and Southam, 1985: 81). The disease increases in frequency and severity with age (Hillson, 1996: 266-7). Analysis of archaeological bones commonly associates periodontal disease with diet, particularly in cases of gross nutritional deficiency (Soames and Southam, 1985: 83). Recent clinical research has suggested that there are strong associations between periodontal disease and intake of calcium, vitamin C, and a number of antioxidants (Nishida *et al.*, 2000; Chapple *et al.*, 2007; Yu *et al.*, 2007; Moynihan, 2012: 100). Vitamin C, in particular, is crucial in preserving and repairing tissues of the periodontium, e.g. maintaining the structural integrity of the periodontal ligament, and formation of collagen, alveolar bone and blood vessel walls (Moynihan, 2012: 100). Furthermore, periodontal disease is more prevalent in nutritionally deficient populations (Enwonwu, 1995; Moynihan, 2012: 100).

Diet was analysed by calculating true and crude prevalence of macroscopically observed (aforementioned) dental pathological conditions in each dentate individual, comparing observed prevalence at York with data from the 11 comparative towns. True prevalence is the percentage of teeth affected by a dental pathological condition, whereas crude prevalence is the number of individuals affected. Dental pathological conditions were recorded as present or absent per tooth, except for periodontal disease which was recorded as present or absent per dentate individual. Periodontal disease was recorded per individual in order to maintain consistency with comparative data (Roberts and Cox, 2003: 135). Dental calculus, enamel hypoplasia, and dental caries, were not scored for location or severity. Total numbers of teeth (as well as total numbers of teeth per tooth type) were calculated from the dental inventory. Total number of empty tooth sockets (where teeth were lost post-mortem) was calculated, as was total number of teeth lost ante-mortem. True prevalence rates (TPR) were calculated for each dental pathological condition by using the following equation (after Roberts and Cox, 2003), where (a) is the number of teeth affected and (b) is the total number of teeth observed:

$$TPR\% = \left(\frac{a}{b}\right)100$$

Crude prevalence rates (CPR) were also calculated where applicable (e.g. for periodontal disease, because of inconsistency in the recording methods used in different osteological reports and publications), for comparison with other assemblages where TPR data was not available. CPR was calculated using the following equation, where (a) is the number of individuals affected and (b) is the total number of individuals observed:

$$CPR\% = \left(\frac{a}{b}\right)100$$

For the assemblages from comparative towns, raw data was utilised where possible to calculate comparative prevalence rates. If raw data were not available, prevalence rates were derived from the relevant reports. For some sites, data were not available; data tables shown in each section should be referred to in order to ascertain from which reports comparative figures are derived.

TPR (or CPR) of each dental pathological condition were compared with given rates from other, comparative assemblages. Differences in prevalence rates between sites and sexed individuals were tested statistically. Chi-square testing compares observed data with expected data, where expected data represents an idealised data distribution that is the result of random variation. The chi-square tests observed data against the expected data to see whether the observed data could be the result of natural variation from a random distribution. Chi-square testing was conducted in Microsoft Excel in order to test for significant differences in prevalence rates between York and the comparative towns.

Microsoft Excel was utilised for between site testing as raw data is not required to be entered separately for every individual case, as in other statistical programmes such as SPSS Statistics 19. The vast amount of raw data required to calculate true prevalence of dental pathological conditions at each town can instead be tested in Microsoft Excel using total counts. This method requires manual calculation of expected values (where programmes such as SPSS would automatically calculate expected values) and the chi-square value. Calculation of the expected number of affected teeth (EAT) for each town was conducted using the following equation, where (a) is the total number of teeth at the town in question, (b) is the total number of affected teeth across all towns, and (c) is the total number of teeth across all towns:

$$EAT = \left(\frac{ab}{c}\right)$$

The expected number of unaffected teeth was calculated for each site using the same equation, but this time where (b) is the total number of unaffected teeth across all towns.

The total chi-square value was calculated manually for each town, firstly by calculating two separate values for the number of observed/expected affected teeth and the number of observed/expected unaffected teeth. For example, the first value, relating to the number of affected teeth (NAT), was calculated as follows, where (a) is the number of observed affected teeth at the town in question, and (b) is the number of expected unaffected teeth at the town in question:

$$NAT = \frac{\big((a-b)(a-b)\big)}{b}$$

The same equation was used to calculate the second value, relating to the number of unaffected teeth, but this time where (a) is the number of observed unaffected teeth at the town in question, and (b) is the number of expected unaffected teeth at the town in question. The sum of these two separate values gives the total chi-square value for each town.

Once expected values had been calculated for each town, chi-square tests could be conducted either using all data for all populations, or excluding data for one or more populations. Chi-square tests could also be conducted for single populations, e.g. York, by testing the observed vs. the expected values. In Chapter 4, where chi-square values (and associated p-values) are given for single populations, this is the result of a chi-square test between the observed and calculated expected figures for that one population. The results of all chi-square tests were considered to be significant at the 95% level (where p=<0.05), which indicates that there is a less than 5% probability that the observed result occurred because of random chance.

Crude prevalence rates of dental pathological conditions in males and females from York were also chi-square tested, in order to ascertain whether there were any significant differences in rates between sexes. As a smaller amount of raw data (from just one town) was required for these tests, chi-square tests conducted between York males and females were conducted in SPSS Statistics 19. This also negated the need to manually calculate expected prevalence rates and chi-square values. Again, the result of the chi-square test was considered significant at the 95% level, where p=<0.05.

Prevalences of dental pathological conditions were then used to make inferences about the state of oral health and hygiene in Roman York. Similarly, the data were examined to see if inferences could be made about diet. Prevalence of each of the aforementioned dental pathological conditions was considered. Where high prevalence of a dental pathological condition was observed, it may be suggested that the population were consuming higher quantities of the relevant dietary component, e.g. high prevalence of dental caries may indicate a diet rich in cariogenic foods. Where low prevalence of a dental pathological condition was observed, it may be suggested that the population was consuming smaller quantities of the relevant dietary component, e.g. low prevalence of dental caries may indicate a diet containing few cariogenic foods. The results of these observations were then compared to contemporary evidence for diet and available foods in Roman York, Roman Britain, and the wider Empire, in order to try and establish whether the observed dental pathological patterns and inferred dietary components match up to known/likely dietary components (and also whether known/likely dietary components could produce the observed dental pathological pattern).

Additionally, macroscopically observed osteological data from this study were compared to the results of stable carbon and nitrogen isotope analysis of bone collagen from samples taken from individuals from both the Trentholme Drive (42 individuals) and Blossom Street (19 individuals) assemblages (Müldner and Richards, 2007), faciliting comparison between macroscopic evidence for dental pathological conditions relating to specific food groups and broad evidence for dietary pattern ascertained by isotopic evidence. This study found that carbon and nitrogen stable isotope values for individuals from both Trentholme Drive and Blossom Street were not significantly different (Müldner and Richards, 2007: 690). Individuals from both assemblages were found to have diets that consistently contained low levels of marine foods (Müldner and Richards, 2007: 690). The extensive dataset compiled by Jay and Richards (2006) for Iron Age communities in Yorkshire was also used as a measure of regional diet prior to Roman occupation.

Dental wear is directly associated with diet as it is the result of interaction between the dentition and foodstuffs being consumed by the individual as well as tooth on tooth contact during this and other processes (Hillson, 1996: 231 and 242). Levels of dental attrition can also be affected by factors such as culinary practices, food processing techniques and non-dietary (occupational) tooth wear (Powell, 1985; Walker and Hewlett, 1990). For each dentate individual, severity of occlusal dental wear on the first and second maxillary and mandibular molars was examined. As age at death could be a confounding factor - older individuals tending to have more severe dental wear due to longer duration of use of teeth - dental wear was therefore compared to the mean age assigned by the auricular surface and pubic symphysis as outlined by Steckel *et al.* (2006).

Levels of tooth wear were examined in order to make inferences about coarseness of diet. Mean ages calculated using pelvic auricular surface scores (after Lovejoy *et al.*, 1985) were compared to mean ages calculated using dental occlusal wear scores for all available first and second molars in the same individuals (after Miles, 1963 and Smith, 1984). The same comparisons were made using mean ages calculated from pubic symphysis age scores (after Brookes and Suchey, 1990) and dental occlusal wear scores. A total of 27 individuals had available auricular surface and occlusal wear scores for one or more of the appropriate molars. A total of 20 individuals had available pubic symphysis and occlusal wear scores for one or more of the appropriate molars. As sample numbers are low, these results are of limited applicability to the wider population; therefore results should be regarded cautiously. Comparison of calculated mean ages using this method would determine whether individuals were more likely to be aged as younger, the same, or older using occlusal wear as opposed to the two pelvic methods. As occlusal wear is facilitated by tooth on tooth contact (attritional wear) and abrasion (contact between the tooth and other abrasive particles, such as food; Hillson, 1996: 231), and it may be assumed that a large proportion of this wear results from mastication. Therefore, differences between pelvis and dental age scores are likely to be the result of diet. For the purposes of this exercise, a younger dental mean age could imply that the diet was relatively soft (less attrition and abrasion causing less tooth wear); an older dental age could imply that diet was relatively coarse (more attrition and abrasion causing more tooth wear). This would permit the data to be effectively normalised for age, thus revealing any patterns of dental wear likely to be the result of diet rather than age at death.

Evidence of dental pathology and occlusal wear from this study was compared with other archaeological data concerning dietary habits from York, and archaeological and historical data concerning dietary habits in the Romano-British period in general (e.g. Hall, 2000; O’Connor, 2000; Alcock, 2001; Fuller *et al.*, 2006; Peck, 2009). Inferences could then be made about contemporary diet and how diet in York compared with data from Roman period cemeteries elsewhere in Britain and the Roman Empire. It was then possible to assess any implications this may have concerning food resources for the population of Roman York (also incorporating the demographic findings), and to relate this to likely available dietary sources.

3.3.4. State of Health

Observed pathological conditions (both observed osteologically by the author and in collated osteological reports) were quantified from the skeletal database. Each pathological category is described in the relevant section in Chapter 4.

Total (minimum) numbers of each skeletal element were calculated using the skeletal inventory. Where applicable, true prevalence rates (TPR) have been calculated. Where it was impractical to calculate TPR, crude prevalence rates (CPR) were calculated. Unless stated otherwise, TPR and CPR were calculated using the equations stated on page 105 in this chapter, substituting skeletal elements for teeth.

True fracture prevalence was calculated per skeletal element, and was calculated using raw data for the observed number of skeletal elements expressing evidence for ante-mortem fracture (using the calculation discussed on page 105). True prevalence of joint disease was calculated per affected skeletal element, and also per joint. True prevalence per skeletal element was calculated using raw data for the observed number of skeletal elements affected by the lesions described above (pages 72). True prevalence per joint was calculated using the same TPR calculation (page 105), substituting the number of affected skeletal elements with the maximum number of affected joints present. For example, TPR in the left acetabulofemoral (hip) joint was calculated using the number of affected left femora (n=59/736), as more femora were present than acetabula (n=31/177 affected). These calculations provide minimum TPR.

TPR (or CPR) for each non-dental pathological condition were compared with given rates from comparative assemblages. Comparisons between populations from different archaeological assemblages can be difficult, as a consequence of inherent differences in bone preservation (resulting from environmental conditions, taphonomy etc), differential recording methods and so on. Therefore, differences in crude pathological condition prevalence rates between York and the comparative towns were tested statistically to assess whether any differences were significant. As with dental pathological prevalence, chi-square tests were conducted in Microsoft Excel when testing prevalence rates between towns, and in SPSS Statistics 19 when testing between males and females from York. Manual calculation of expected values and chi-square values was conducted using the same equations as discussed in relation to dental pathological prevalence (page 106), substituting the number of affected/unaffected individuals for teeth. Where applicable, chi-square tests were also run in SPSS to test between manifestation of pathological conditions in the left and right sides of the body (i.e. in conditions that may occur preferentially on one side of the body such as os acromiale), and to test proportional survival/recovery of skeletal elements across excavated sites in York. All graphs were produced in SPSS Statistics 19. Where two variables were tested across two categories (i.e. where presence/absence of cranial trauma per skeletal element was tested between burial locations), the Continuity Correction value was calculated instead. Where sample size is very small, the Pearson chi-square may overestimate the significance of the result: Yates' Continuity Correction corrects the significance of the chi-squared value to account for this potential error and produce a more conservative p-value (Yates, 1934).

The SPSS Statistics 19 programme states that it is not appropriate to use a chi-square test in cases where at least one expected number of affected individuals was less than five. Where expected counts were too low to produce a valid chi-square result, a Fisher's Exact test was used instead to to assess whether any differences between populations were significant. Furthermore, there were several pathological conditions for which the number of cases tested statistically was so great, insufficient computer memory meant that the Fisher's Exact method could not be completed. Where this was the case, the Monte Carlo method was implemented instead. The Fisher'sExact method tests data against all possibilities, whereas Monte Carlo method tests on a reduced number of possibilities in order to use less computational processing power (Field, 2007: 547).

Assessment of the health status of the population of Roman York was made, as were comparisons between the York skeletal samples and data recorded from other contemporary skeletal collections in Britain and other parts of the Roman Empire. Observations were also made concerning discernible differences between visible social and occupational status categories within the population.

3.4. Summary

To summarise, bioarchaeological data for individuals from Roman period York were used in the present study to determine the demographic composition, population size, likely dietary patterns and health status of this urban population. All skeletal remains are derived from burial locations within a 5km radius of the Roman fortress at *Eboracum*, situated in the centre of modern day York. Osteological data for individuals from 11 other Romano-British urban sites were used for comparison.

Osteological indicators of biological age, sex, living stature, dental pathological lesions and non-dental (skeletal) pathological lesions were observed and recorded. Observations were recorded following standard osteological guidelines (Brickley and McKinley, 2004). Raw palaeodemographic data were subjected to statistical modelling in order to eradicate inherent bias associated with osteological methodology, in order to examine mortality rates and likely population size. All pathological data were subjected to thorough statistical analysis, in order to assess whether observed disease rates were within expected prevalence ranges for the time period. The statistical results were then considered in relation to relevant archaeological and historical data, in order to make inferences about likely dietary components and the general health status of the population. The results of all these analyses are presented in Chapter 4.

Chapter 4: Results

This chapter presents the results of the study, divided into the following sections: demography; spatial density analysis; population size; diet; and health. Analysis of the demography includes calculated minimum number of individuals, stature, sex, and age structure of the population. Spatial density analysis calculates burial density and examines cemetery location. The discussion of population size calculates the approximate size of the living population based on burial density and military/civilian settlement size. Study of diet involves examination of prevalence of dental calculus, enamel hypoplasia, dental caries, ante-mortem tooth loss, periapical cavities and periodontal disease, and also considers coarseness of diet. Analysis of health involves examination of prevalence of trauma, congenital/development conditions, circulatory conditions, joint disease, infectious disease, metabolic conditions, neoplastic disease and other miscellaneous pathological conditions.

4.1. Demography

4.1.1. Minimum Number of Individuals (MNI)

A summary of MNI is presented in Table 4.1. Overall, the calculated MNI for the York assemblage utilised in this study was 785 individuals.

	n	**Based on**
Inhumations	663	No. discrete interments
Cremations	79	No. discrete deposits
Disarticulated Material	43	No. L. femora
Total	**785**	

Table 4.1: Minimum number of individuals

4.1.2. Stature

Stature range and means were calculated for the York assemblage using long bone data from 165 males and 61 females. These comprise 21.02% and 7.77% of the total York assemblage respectively. In terms of comparative data, stature was not calculated for any individuals from Brougham as all individuals were cremated and thus complete long bone length data were not available. Comparative data from south and west London were not included, as stature had only been calculated for four and six individuals respectively. It was, therefore, decided that for London, only data from East London would be utilised when examining stature. Stature distribution and mean values for York and the remaining ten comparative assemblages are presented in Figure 4.1. The purple boxes represent the second and third quartiles, the whiskers represent the range, and the black line the mean.

Comparison of mean heights of males and females from York shows that, on average, male individuals in the York assemblage are 12cm taller than females. This fits the known pattern for urban settlements in Roman Britain; for example, an average height difference of 12cm was recorded in the most recently excavated assemblage at Lankhills, Winchester (Booth *et al*., 2010: 354). Average height differences of 11.2cm and 11cm were also recorded between males and females at Cirencester (McWhirr *et al.*, 1982: 140) and East London (Barber and Bowsher, 2000: 286) respectively. Therefore, mean height difference between sexes within the case study sites is as expected for the period.

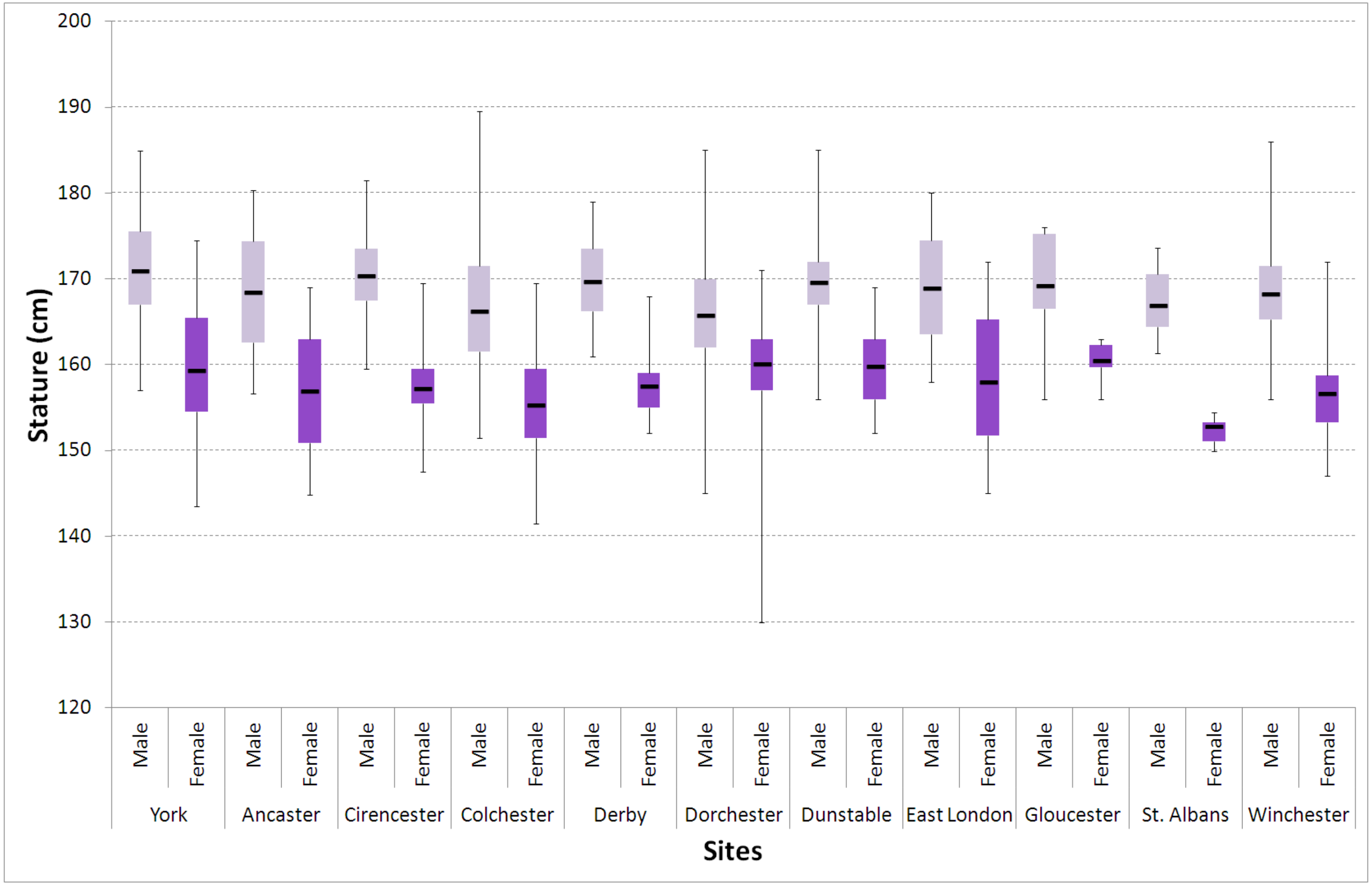

Figure 4.1: Male and female stature at York and all comparative towns

Mean female stature at York (159.32cm) matched the mean stature for Romano-British females calculated by Roberts and Cox (159cm; 2003: 163). However, the York female mean was higher than the female mean from seven of the 11 comparative towns. The largest observed difference was with the St. Albans assemblage, where on average, females were 6.52cm shorter than females from York. However, shorter stature at St. Albans may be a product of the smaller assemblage size, meaning that the results may be slightly less representative of genuine male and female stature ranges within living population. The other comparative assemblages are (with the exception of Derby) of a substantial sample size and hence calculated values are more likely to be representative. Of the seven assemblages with shorter values, female mean height ranged from 1.32-4.02cm shorter than at York. Of the three comparative towns with higher values, Dorchester (160.17cm) and Dunstable (159.66cm) were not markedly higher, and the Gloucester (160.5cm) result is again likely to be a product of small sample size. Thus, it appears that while the York females are of expected height for Roman Britain, they are on average, slightly taller than females at other urban settlements during this period.

Mean male stature at York (170.96cm) was approximately 2cm greater than the mean stature for Romano-British males calculated by Roberts and Cox (169cm; 2003: 163). The York male mean was also higher than averages calculated for males from all other comparative towns; the largest observed difference was with the Dorchester assemblage, where on average, males were 5.20cm shorter than males from York. As with the figures calculated for females, figures for males from Derby, St. Albans and Gloucester may be unrepresentative because of the small sample size; all other comparative towns have sample sizes large enough to infer that calculated figures are representative of the living population. It is, therefore suggested that the York males are slightly taller than expected for Romano-British urban towns.

4.1.3. Sex

Of the 785 discrete individuals, 464 (59.11%) were classified as being male or female, possibly male or female, or of indeterminate sex. The remaining 324 individuals were not sexed, either because they were sub-adult skeletons (including adolescents), or because they were too incomplete. Sex distribution for the York assemblage and all comparative assemblages is presented in Figure 4.2.

Figure 4.2 shows that the York sex ratio was calculated at 1.88 males for every one female. Modern human populations have a sex ratio at birth that usually averages at 1.05:1, though the operational sex ratio for adults is usually closer to 1:1 due to greater mortality of males during the developmental period (Schmitt, 2005). Therefore, the York assemblage has a noticeable bias towards male individuals. This bias, however, is much less exaggerated than previous research into the population of Roman York would suggest. For example, original analysis of the Trentholme Drive assemblage calculated a sex ratio of "approximately four" males for every one female (Wenham, 1968: 147), but the more recent study of the Trentholme Drive assemblage by Peck (2009) produced a sex ratio of 1.76 males for every one female. The sex ratio produced by this latter study demonstrates a marked reduction in the male bias originally proposed by Wenham (1968). This is likely to be a result of changes in osteological methodology in the time between the two studies taking place, and will be discussed further in Chapter 5.

Derby, Brougham and St. Albans have higher proportions of females than males. Dorchester, Winchester and Dunstable have sex ratios that approximate the expected ratio proposed by Schmitt (2005). Colchester, London and Ancaster have a slightly higher proportion of males. York, Cirencester and Gloucester have considerable male bias. Figure 4.2 clearly shows that of all the assemblages examined in this study, York has the third highest proportion of males (65.33% of sexed individuals).

Sex ratios from all 12 towns were tested statistically with the chi-square test in SPSS 19, using a 95% confidence interval (p=0.05). Of the tested towns, six had sex ratios that were significantly different from expected values (Table 4.2). Sex ratios at the remaining six towns are therefore likely to have occurred by chance, or reflect normal variations in population composition.

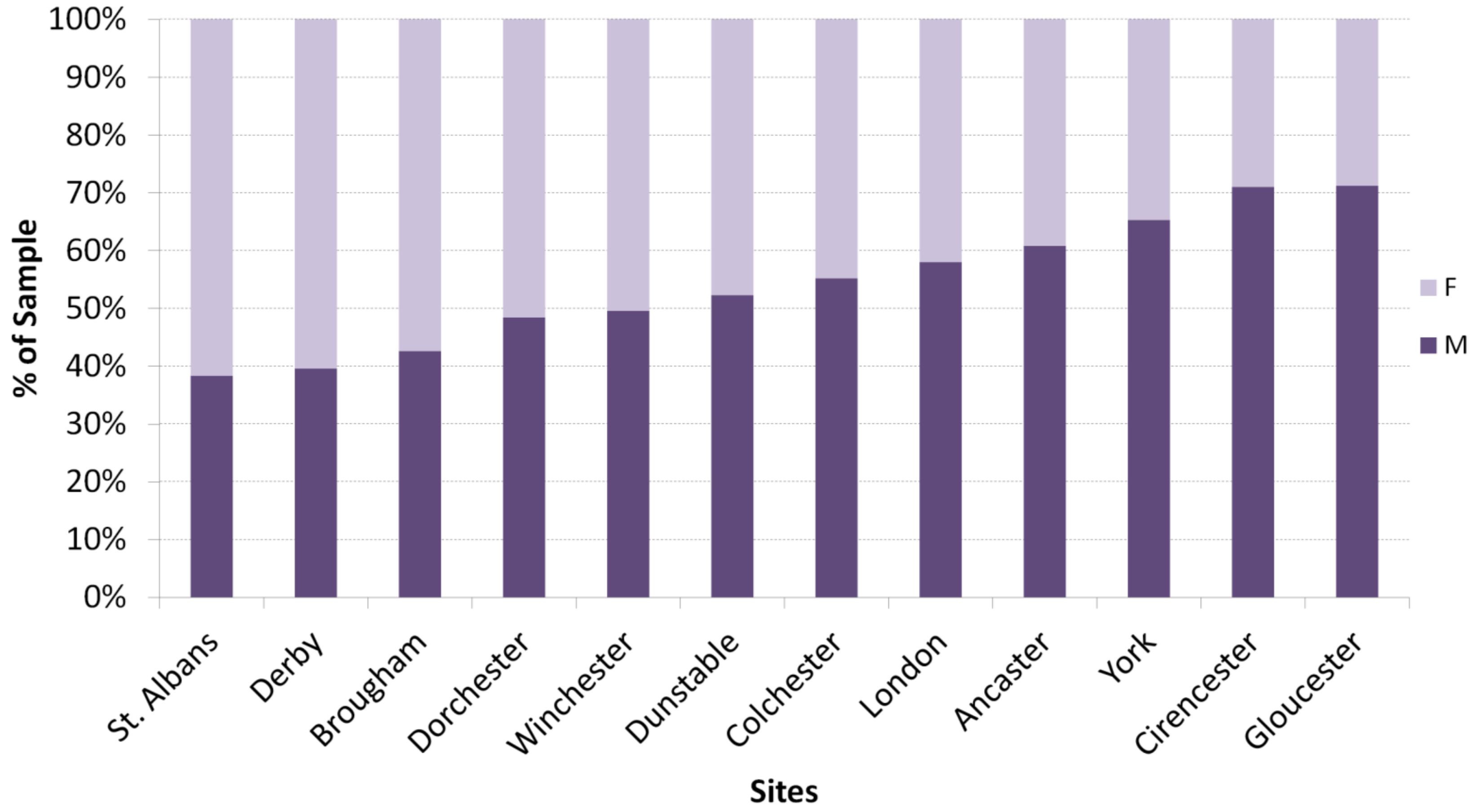

Figure 4.2: Sex ratios at York and all comparative towns

York				
	Observed	**Expected**	χ^2	**P value**
Males	294	225	42.32	<0.01
Females	156	225		
Total	450	450		
St. Albans				
Males	54	70.5	7.723	0.<01
Females	87	70.5		
Total	141	141		
London				
Males	249	214.5	11.098	0.01
Females	180	214.5		
Total	229	229		
Ancaster				
Males	129	106	9.981	0.02
Females	83	106		
Total	212	212		
Cirencester				
Males	245	172.5	60.942	<0.01
Females	100	172.5		
Total	345	345		
Gloucester				
Males	62	43.5	15.736	<0.01
Females	25	43.5		
Total	87	87		

Table 4.2: Significant chi-square test sex ratio results

Table 4.2 demonstrates that York, London, Ancaster, Cirencester and Gloucester all have significant male bias within the population. St. Albans is the only site that has a significant female bias. Sex bias in Roman Britain has been discussed extensively in the literature, with numerous explanations given for the various ratios of males to females. Reports on Romano-British urban cemetery assemblages frequently encounter male bias; explanations offered for this include preservation bias, military presence, presence of retired soldiers, selective infanticide, migration, and cultural separation of males and females at cemetery sites (Wenham, 1968: 147; Clarke, 1979; 123; McWhirr, 1982: 135; Cox, 1989: 7; Davison, 2000: 232; Watts, 2001: 336-338). These, as well as other possible factors, will be discussed in Chapter 5.

Some degree of sample bias is likely to be present amongst at least some of the observed assemblages, simply because of the nature of archaeological investigation and the way in which areas of land are selected for excavation. However, these biases are also likely to be cemetery/site specific; as this study consolidates data from multiple assemblages across a wide range of sites, any sample bias should, theoretically, be evened out. To test this, the five cemetery assemblages yielding more than 20 discrete burials were examined statistically in terms of sex ratio. Significant male bias was clearly found at the 1-3 and 6 Driffield Terrace sites, where no female skeletons were observed. Chi-square testing could not be conducted on these two sites because of absence of females. Chi-square testing in SPSS 19 across the other three cemetery assemblages showed that significant male sex bias was present at one out of the three sites at a 95% confidence interval ($p = < 0.05$; Table 4.3). Male bias was also found when sex distribution was tested across all other sites (with less than 20 burials). This finding will be discussed in relation to burial zoning and population structure in Chapter 5.

Site	**χ**	**p**
Lion and Lamb Car Park	1.19	0.275
York Railway Station	3.449	0.063
Trentholme Drive	16.427	<0.01
All sites with <20 burials	9.127	<0.01

Table 4.3: Skeletal assemblages with significant male bias

4.1.4. Age at Death

Model mortality curves are presented in Figure 4.3. These curves represent proportion of deaths (*dx*) in each age category for model populations with an average life expectancy of 20 years (e0=20) and 30 years (e0=30). This figure also shows the proportion of deaths (*dx*) in each age category for Roman York.

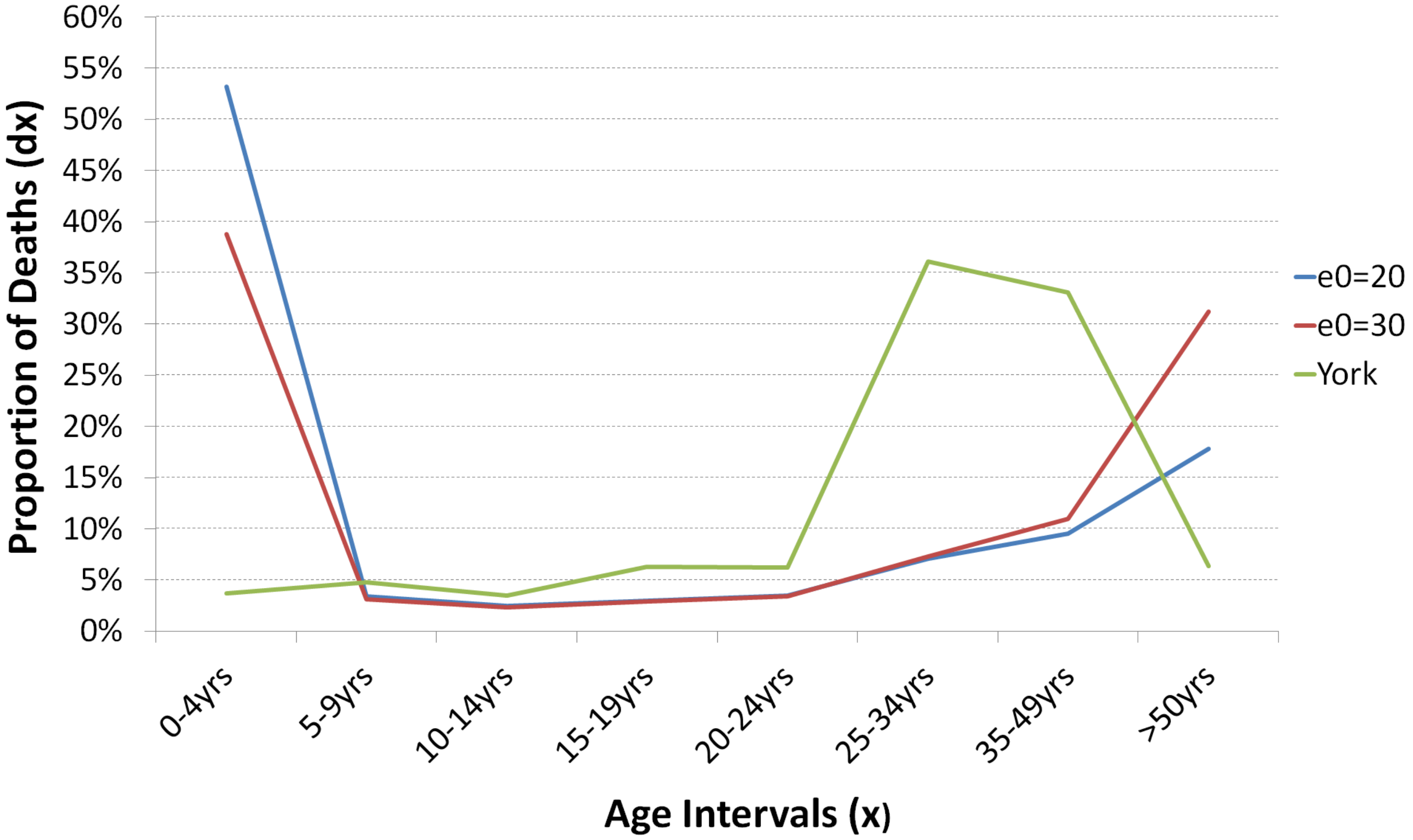

Figure 4.3: York vs. Model "West" females dx curve (constructed using late nineteenth to mid-twentieth century mortality data for females from Australia, Belgium, Canada, Denmark, Britain, Estonia, Finland, France, Ireland, Israel, Japan, Latvia, Luxemburg, the Netherlands, New Zealand, Sweden, Taiwan, South Africa and the United States; Coale and Demeny, 1983: 12)

It is immediately clear that there are a number of differences between the *dx* curve produced for Roman York and curves produced for model populations. Firstly, York has significantly fewer individuals in the 0-4 year age category: the model curves predict between 40-50% mortality in this age range, whereas the York data suggests less than 5%. Under-representation of infants is frequently documented in archaeological cemetery assemblages. Destructive post-depositional processes frequently have a greater degree of impact on the preservation of sub-adult bones (Gordon and Buikstra, 1981: 569; O'Shea, 1984: 25 and 52). Taphonomic factors such as water level, soil type, soil movement, burial depth, temperature, bioturbation and manner of burial all contribute to bone preservation; the porosity and low mineralisation of infant bones also mean that the remains of young individuals are more likely to be affected by these factors to a greater degree (Guy *et al.*, 1997: 225; Field Archaeology Specialists 2005a: Aix). These factors can, in turn, lead to poor survival rates and potentially lower recovery rates by archaeologists (Chamberlain, 2006: 89). Furthermore, due to their small size, the bones of infants and sub-adults are more likely to be disturbed by bioturbation and by truncation of shallower graves (Buckberry, 2000). In the context of Roman Britain, it has been suggested that infants may have been buried in different locations to the normal cemeteries; infant burials are often found in Romano-British domestic contexts and at rural sites such as villas (Philpott, 1991: 97; Moore, 2009; Mays and Eyers, 2011).

Secondly, the York assemblage has twice as many individuals in the 15-19 year and 20-24 year (adolescent/young adult) age categories as the model curves. Methodologically, age estimation of individuals in these categories is relatively straight forward; epiphyseal fusion occurs primarily between the ages of 15 and 30 years and has proved to be a moderately reliable age indicator (O'Connell, 2004: 18). Therefore, it is possible that over-representation of individuals in these age categories reflects real over-representation in the living population.

Thirdly, York has noticeably more individuals in the 25-34 year and 35-49 year (mid adult) age categories. Like the model curves, the number of adult individuals increases with age, but the numbers peak in the age category 25-34 years rather than in the oldest, 50+ category. York also has a deficit in the number of individuals present in the over 50 years (old adult) age category. This pattern is often demonstrated in archaeological samples (Chamberlain, 2006: 90). Mortality peaks in the young and middle adult age categories are often accompanied by a deficit or absence of individuals in the older adult age brackets; this is attributable to the systematic under-estimation of the ages of older adults (Bocquet-Appel & Masset, 1982 and 1985; Molleson and Cox 1993: 171; Chamberlain, 2006: 90). The aforementioned evidence suggests that taphonomic, methodological and socio-cultural factors are likely to have influenced the mortality curve presented in Figure 4.3. Given the problems of under and over-representation, and the aforementioned ways in which these problems are likely to affect the shape of the mortality curve, it is most likely that the York assemblage is representative of an attritional population.

Figures 4.4 and 4.5 show proportion of deaths (*dx*) in each age category for Roman York and the 11 comparative towns. Two separate graphs were constructed for ease of viewing. As at York, all of the comparative populations have under-representation of infants. The highest infant mortality rate observed in the excavated assemblages, occurring at Dorchester, is still less than 20%. The majority of excavated assemblages also have a mortality peak occurring in the 25-34 year and 35-49 year (mid adult) age categories. In some cases, most notably St. Albans (Figure 4.4), Ancaster and Cirencester (Figure 4.5), this mid adult mortality peak is even more pronounced than in the York assemblage. Again, this is likely to be the result of the osteological methods used in the analysis. These mid adult mortality peaks are therefore accompanied by the expected shortfall in the number of older adults; at Dunstable there is even a complete absence of individuals in the >50 year category. It is noteworthy that all the archaeological assemblages share a pattern of deviation from the model populations. This supports the argument that it is biases in the archaeological data generation that accounts for this issue.

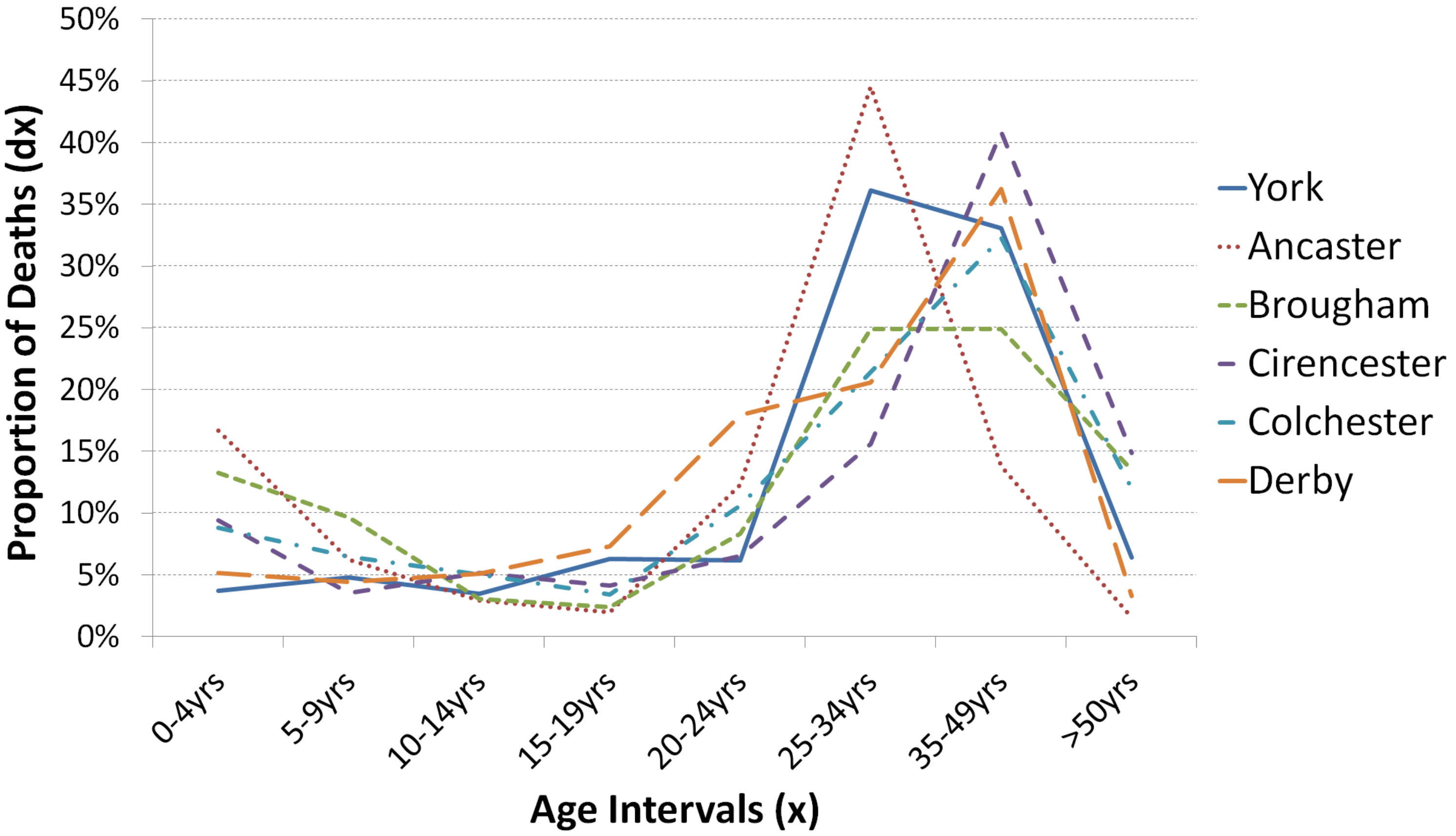

Figure 4.4: York vs. comparative town *dx* curves a)

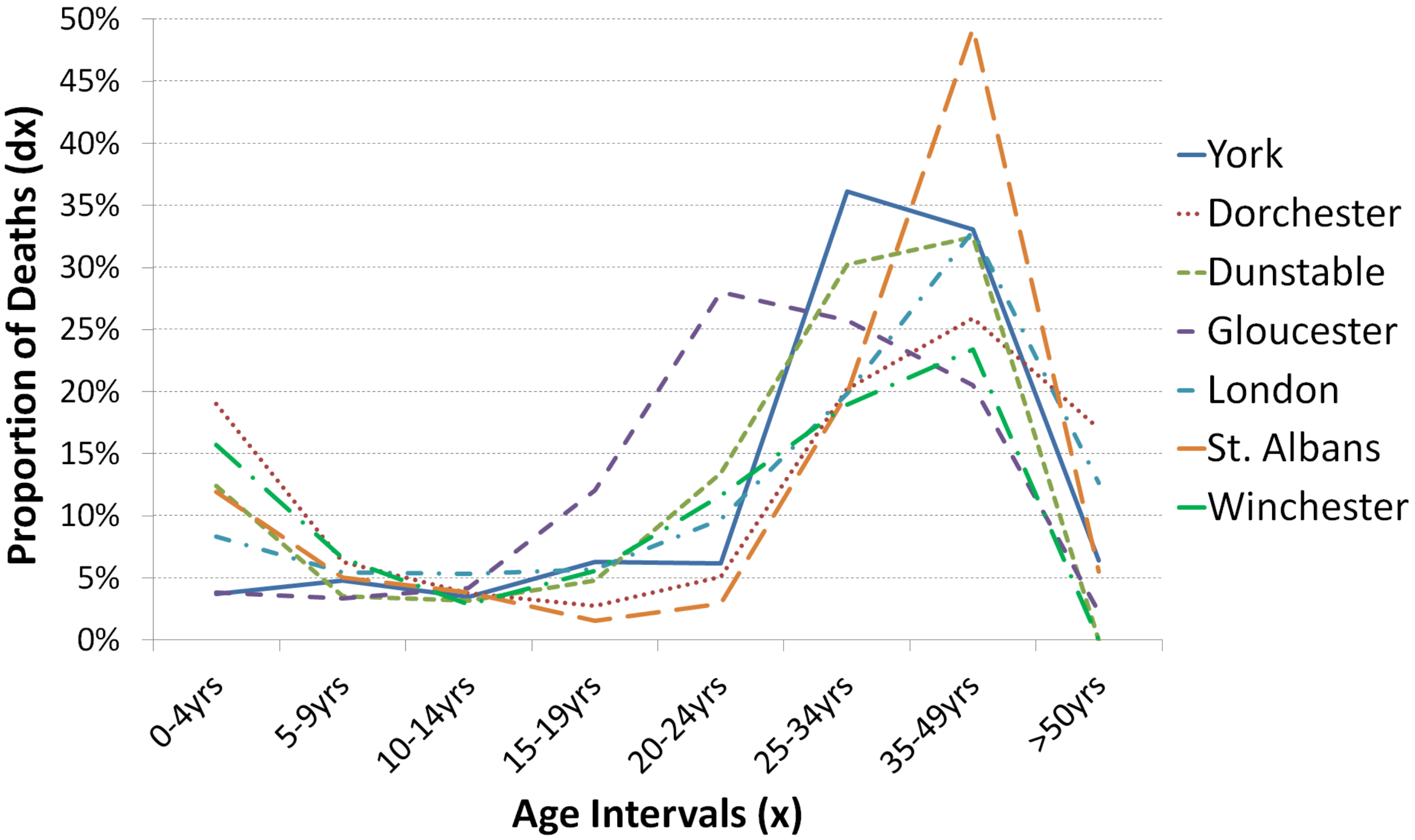

Figure 4.5: York vs. comparative town *dx* curves b)

Of the comparative assemblages, the only one that deviates slightly from the aforementioned pattern, with low numbers of infants and old adults, and a peak in mid adult mortality, is Gloucester. While there is the noticeable under-representation of infants and older adults, there is also over-representation of adolescents, and the mortality peak is observed in the 20-24 year age interval. The Gloucester assemblage utilised in this study does incorporate skeletal data for a group of discrete inhumation burials and a second group of individuals found in a mass grave that are likely to have been the victims of epidemic disease (Simmonds *et al.*, 2008: 29 and 140). The mass grave at Gloucester contains a high proportion of young adult individuals (Simmonds *et al.*, 2008: 40).

Catastrophic mortality profiles are produced when a population has been affected by events such as epidemic disease or natural disasters; all members of the living population are affected indiscriminately, producing mortality profiles that therefore reflect the age structure of the living population (Chamberlain, 2000: 125). As living populations tend to show high proportions of young adults, this is reflected in the resultant catastrophic mortality profile. This inclusion of skeletal data from the mass grave, therefore, explains the differential structure of the Gloucester mortality curve.

Brothwell (1972: 86) suggests that palaeodemographic studies should be undertaken on adult samples only, as the proportion of sub-adults in archaeological samples is often much lower than expected , and hence is unrepresentative of the living population. Under-representation of sub-adults subsequently causes proportional over-representation of adults in all age categories, which consequently injects mortality bias into the study, i.e. sub-adult mortality will appear to be much lower than expected and adult mortality will appear proportionally higher than expected. When calculating life expectancy, under-representation of sub-adults will therefore raise the calculated life expectancy for the population, both at birth and during each age interval. For this reason, the aforementioned data will now be considered using only adult individuals. Furthermore, the adult samples were broken down so that only individuals of known sex were utilised, in order to examine separate male/female mortality in the given age categories. Figure 4.6 shows the proportion of adult male and female deaths (*dx*) in each age category for Roman York.

The mortality profiles for adult males and females in Roman York are very similar (Figure 4.6). Approximately equal numbers of males and females died in the 15-19 year, 20-24 year, and 25-34 year age categories. The main differences appear in the later age intervals; proportionally more males than females died in the 35-49 year category, and proportionally more females than males died after the age of 50 years. This indicates that females may have had a slightly higher life expectancy than males. As with the mortality profile compiled using all aged individuals for Roman York (Figure 4.3), the same data divided into males and females also shows an attritional mortality distributions.

Figures 4.7 and 4.8 show proportion of deaths (*dx*) in adult males in each age category for Roman York and the 11 comparative towns. Figures 4.9 and 4.10 show proportion of deaths in adult females at the same towns.

The mortality distributions presented in Figures 4.7-4.10 indicate that, overall, male populations tend to have lower proportions of younger adult deaths followed by a pronounced mortality peak in the 35-49 year age category. The exception to this is Ancaster where this peak occurs slightly earlier, in the 25-34 year category. It should be noted at this point that extreme peaks and troughs in these distributions, e.g. in both the male and female curves produced for the Ancaster and Derby assemblages, are likely to be the result of smaller sample sizes. Female populations generally have a more even mortality distribution across the adult age categories than the males. As with the male populations, females also tend to have a mortality peak in the 35-49 year category. However, in most of the female populations, this peak is less pronounced than in the males.

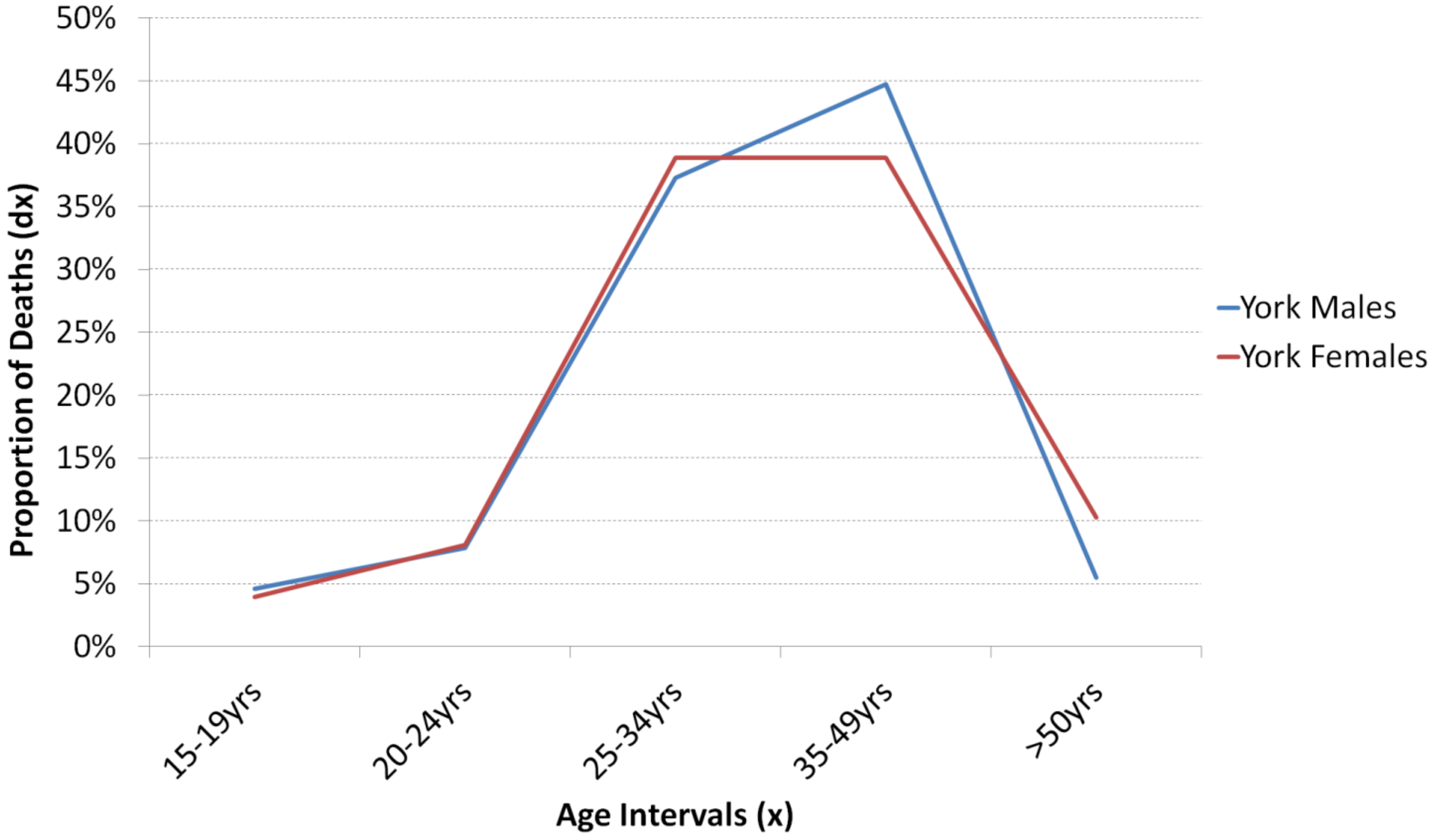

Figure 4.6: York male and female *dx*

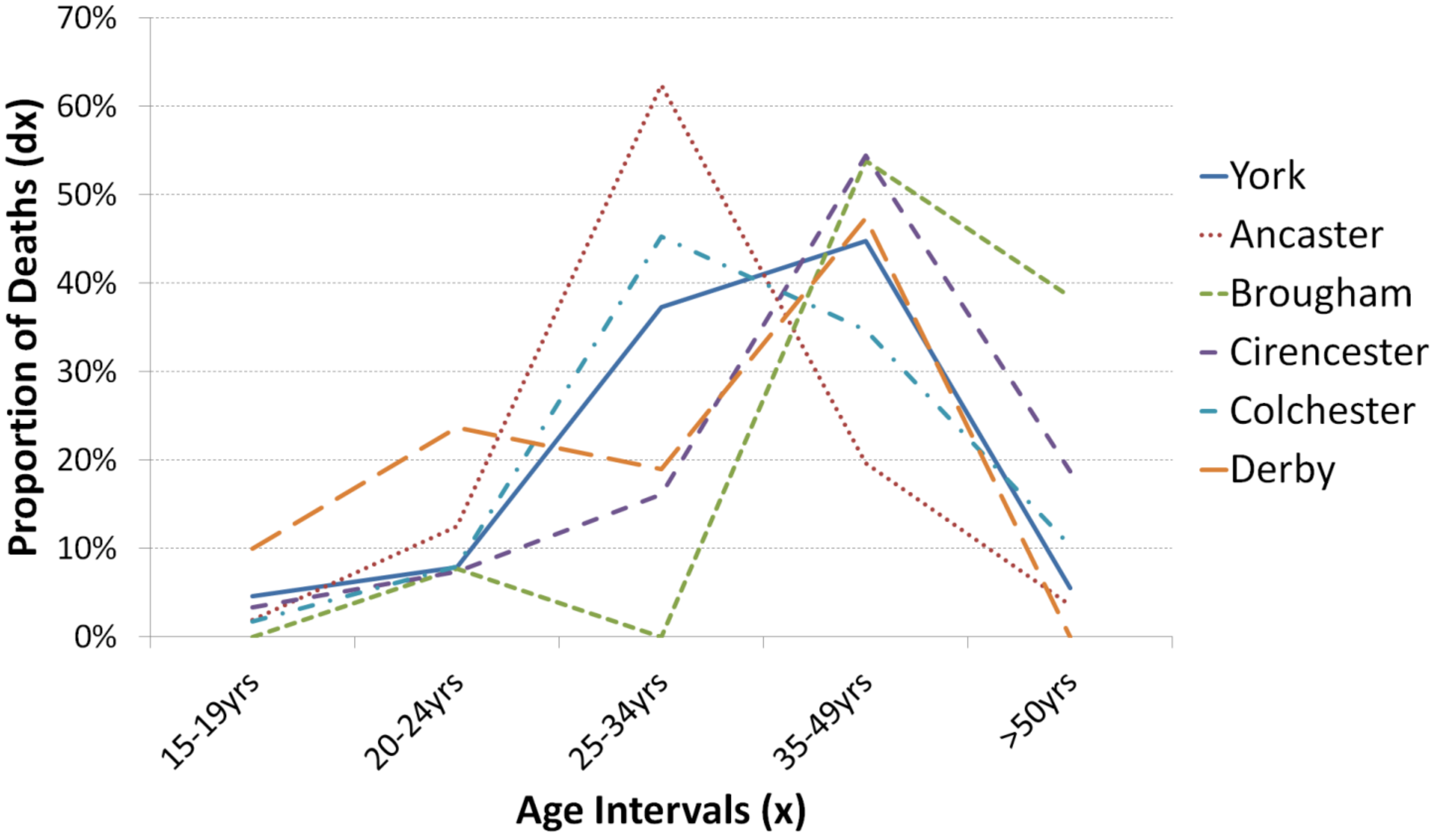

Figure 4.7: Comparative adult male *dx* a)

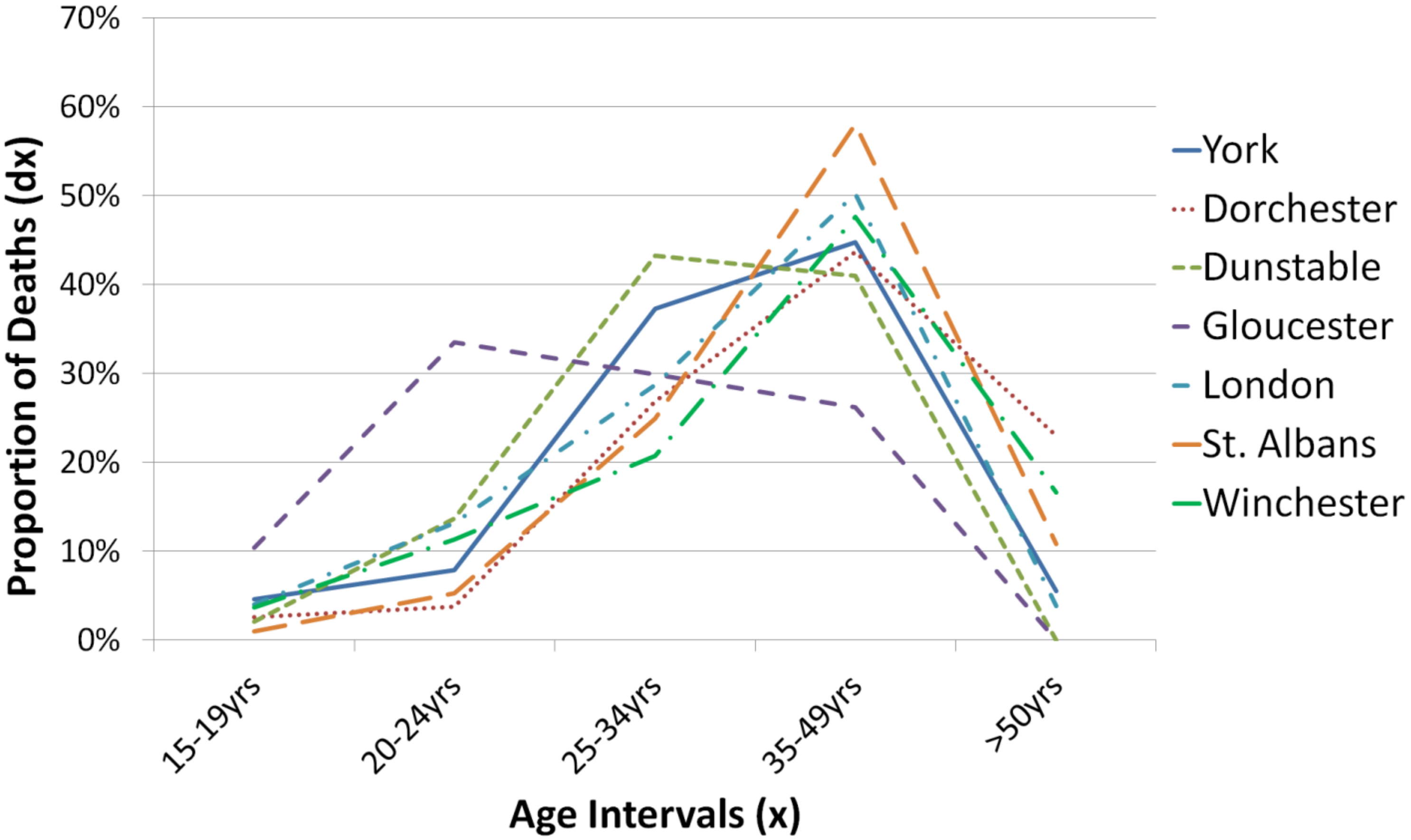

Figure 4.8: Comparative adult male *dx* b)

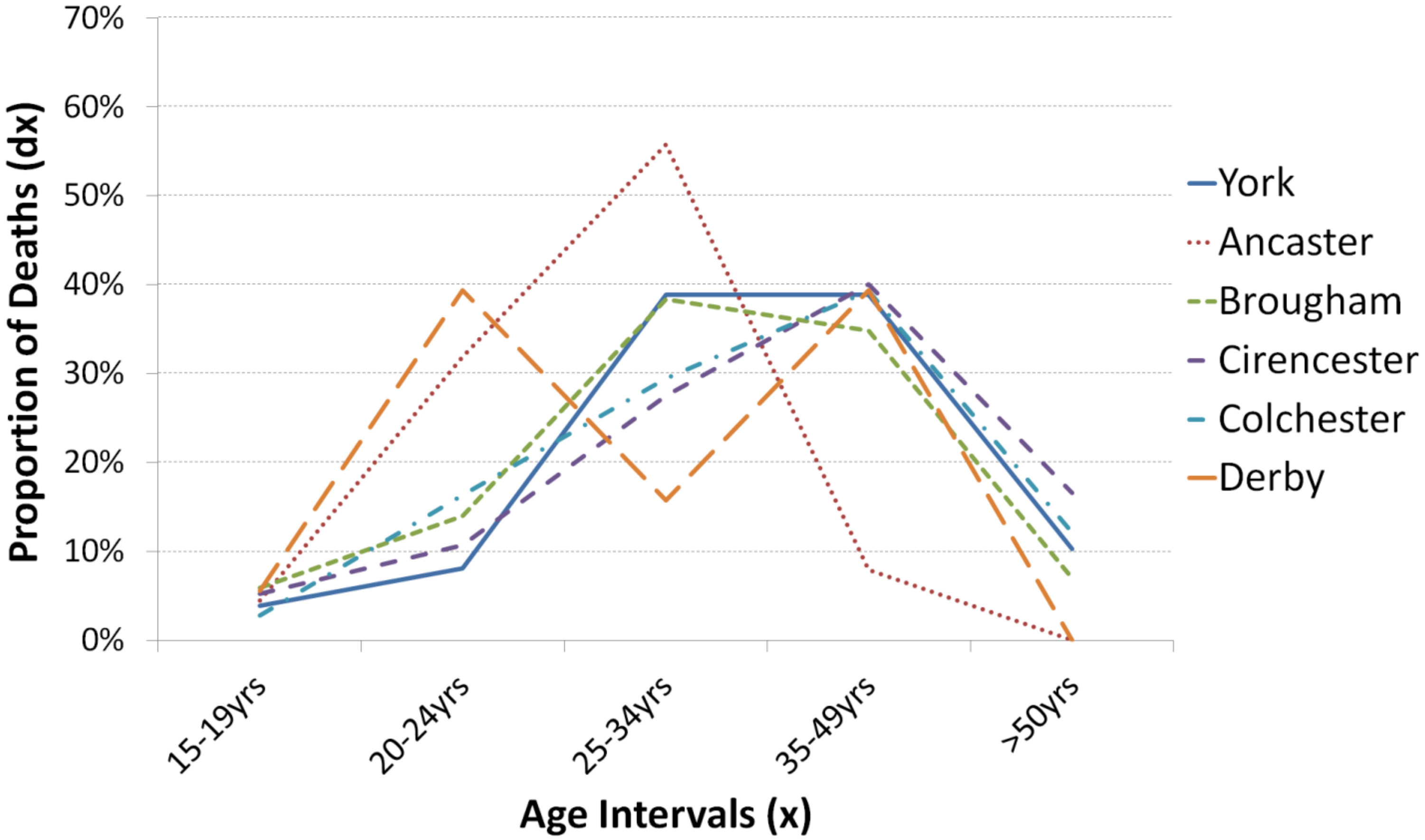

Figure 4.9: Comparative adult female *dx* a)

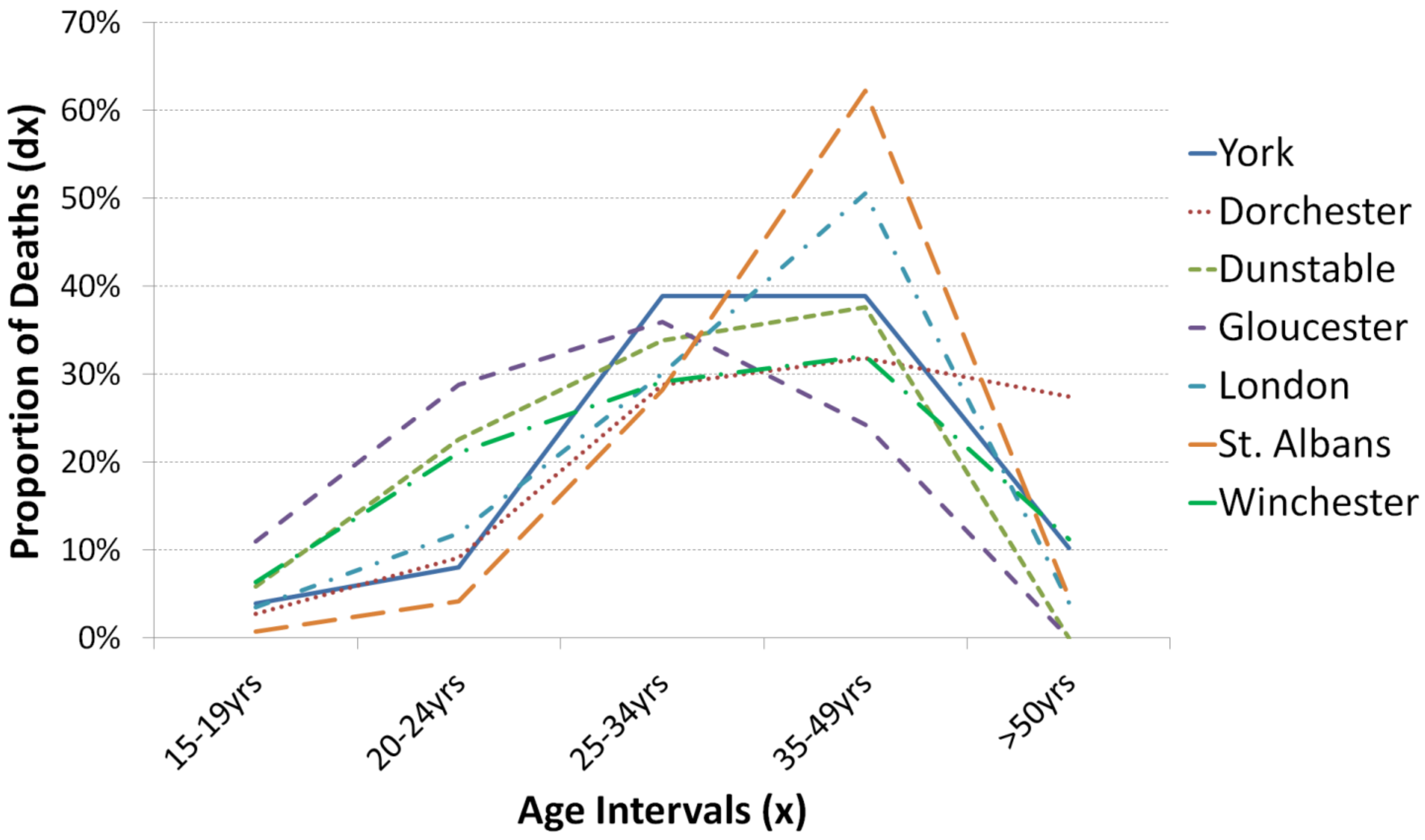

Figure 4.10: Comparative adult female *dx* b)

Generally, there are low proportions of both males and females in the >50 year age category. In the females this is exceptionally low, with 0-10% of deaths occurring in this age category in the majority of populations. Mortality rates for males in the >50 year category are more varied, ranging from approximately 0-20%. The exception to this is clearly Brougham, where approximately 40% of the male population appear to have died after the age of 50. This could result of the smaller sample size combined with the absence of individuals in younger age categories (i.e. 15-19 years and 25-34 years) causing some degree of over-representation in the older adult age brackets.

While the data presented in Figures 4.7-4.10 do still appear to be affected by the methodological issues, they do suggest that, overall, males in Roman Britain are more likely to have a slightly higher life expectancy than females. However, this is not reflected at York. This will be discussed below, in relation to the life tables produced for each assemblage in this study.

The mortality profiles presented so far in this study (Figures 4.3-4.10) were produced using raw osteological data. As previously discussed, these profiles may be subject to bias, e.g. towards the mid adult age categories, as a result of the osteological aging methods used. Indeed, the results obtained do support the suggestion that bias is playing an instrumental role in the overall shape of the distributions created. The next section of this chapter will discuss the Roman York data as Bayesian smoothed mortality profiles, which are designed to minimise such bias (see Chapter 3).

Proportions of deaths (*dx*) in each adult age category for Roman York after application of Bayesian statistical modelling (utilising attritional priors) are presented in Figures 4.11 and 4.12. Figure 4.11 shows the curve produced using smoothed auricular surface scores. Figure 4.12 shows the curve produced using smoothed pubic symphysis scores. Both graphs also include model *dx* profiles for populations with an average life expectancy of 20 (e0=20) and 30 (e0=30) years at birth, adjusted to include adult individuals only. It should be noted that these model curves appear very similar in composition after the removal of sub-adult individuals because of the elimination of differential high infant mortality rates.

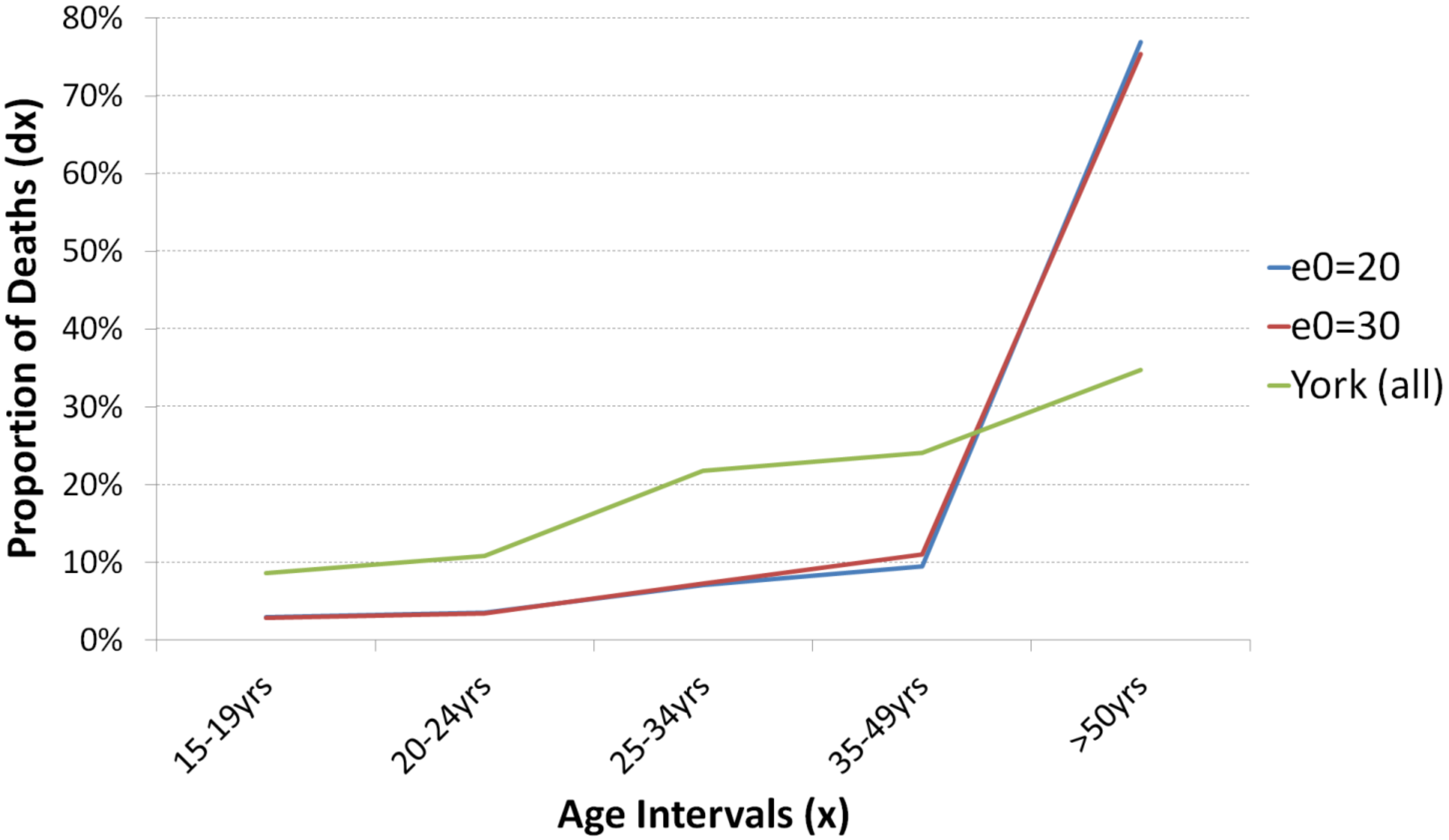

Figure 4.11: York *dx* after Bayesian smoothing of auricular surface age scores

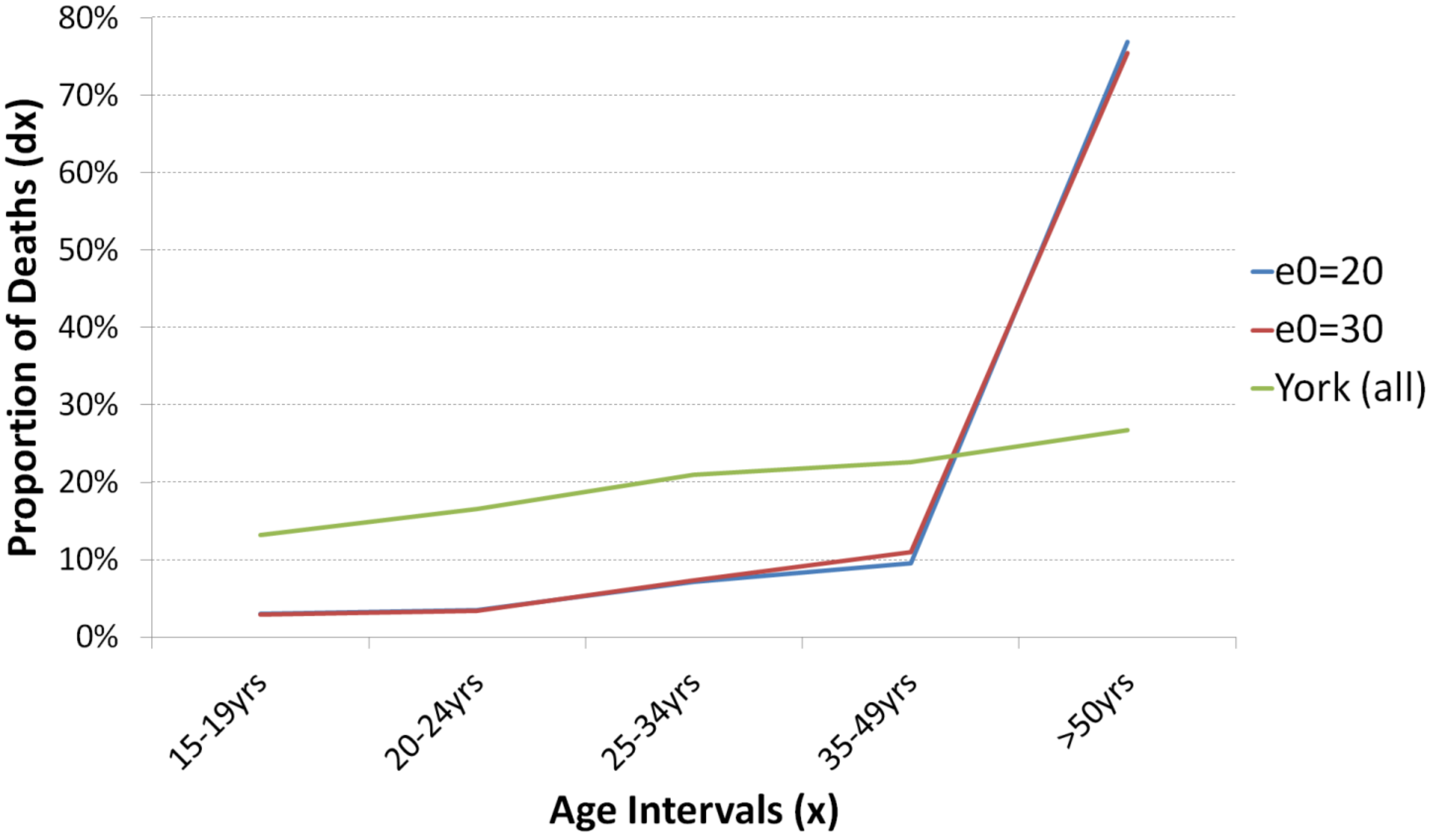

Figure 4.12: York *dx* after Bayesian smoothing of pubic symphysis age scores

Overall, the aforementioned method has produced mortality profiles that appear to be subject to significantly less mid adult bias than the raw data. The York age at death distribution now approximates the model profiles in terms of the shape of the curve and, although it is not as pronounced as in the model distributions, there are now proportions of deaths occurring in the older adult categories (approximately 30% as opposed to around 10% in the profiles constructed using raw data). Both the auricular surface and pubic symphysis profiles show a slight excess of individuals in the 25-34 year age interval; this may, therefore, reflect a real mortality peak in individuals of this age. Although the two model curves are very similar after removal of the sub-adults, the smoothed data are more comparable to the model curve e0=30, suggesting an average life expectancy at birth closer to 30 years.

Figure 4.13 shows smoothed *dx* curves in each adult age category for York, divided into males and females. These distributions clearly show that in the adolescent and young adult age categories, male mortality is proportionally higher. In the mid to older adult age categories, female mortality is proportionally higher. This again suggests that females within the population of Roman York had a slightly higher life expectancy at birth than males. The slight mortality peak observed in Figure 4.11 is also visible in Figure 4.13, and is present in both the male and female distributions.

Life tables were constructed for the York assemblage, as well as all other comparative towns in order to establish life expectancy at birth (Table 4.4). These estimations utilise all aged individuals from each assemblage.

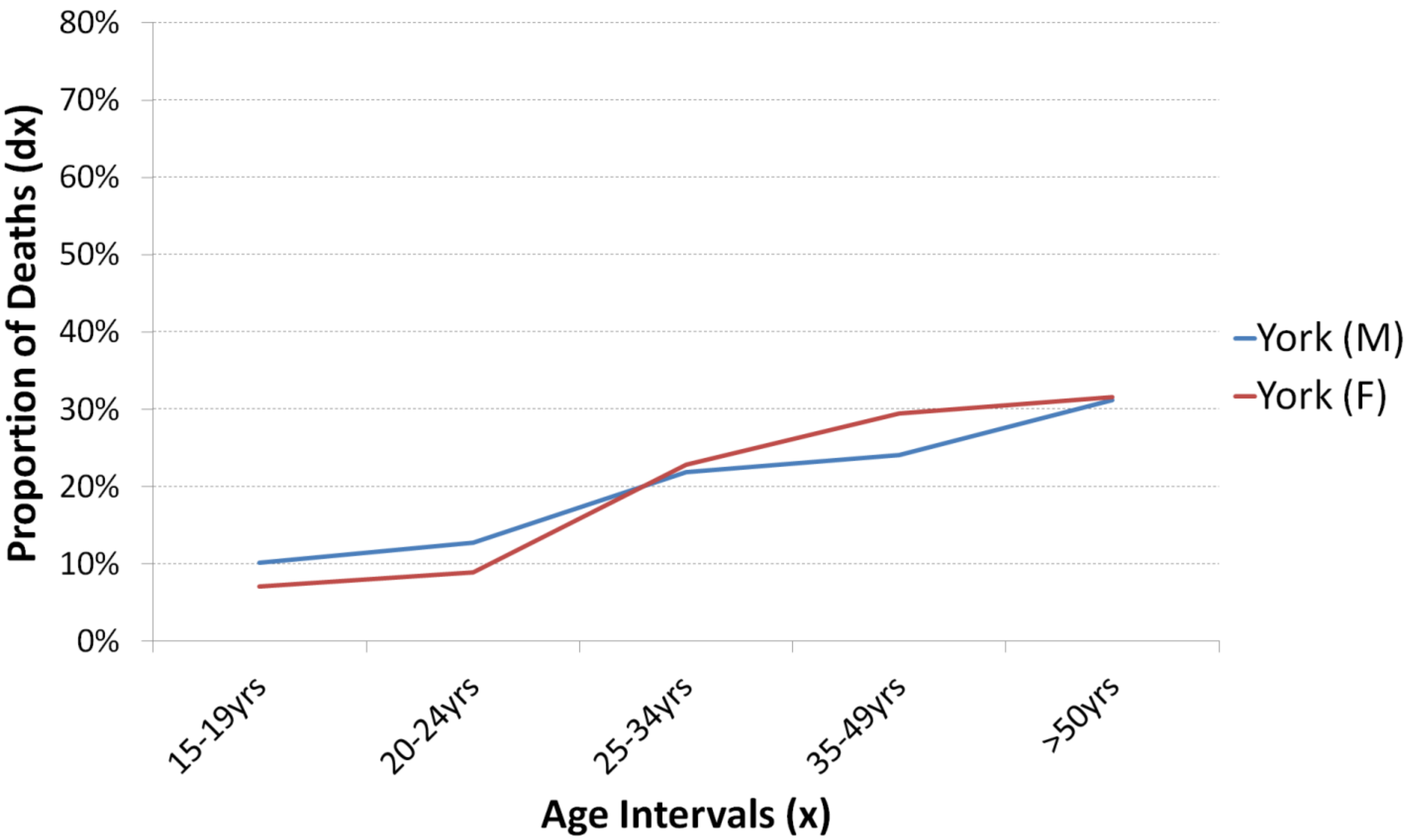

Figure 4.13: York male and female smoothed *dx* curves

Site	**Life Expectancy at Birth (*ex*)**	**Reference**
York	32.26	This study
Ancaster	24.55	Cox, 1989
Gloucester	27.14	Simmonds *et al.*, 2008
Dunstable	27.69	Matthews, 1981
Winchester	30.01	Clarke, 1979; Booth *et al.*, 2010
Derby	30.05	Wheeler, 1985
Brougham	30.23	Bell and Cool, 2003
Dorchester	30.76	Farwell and Molleson, 1993; Davies *et al.*, 2002; Egging Dinwiddy, 2009
Colchester	31.96	Crummy *et al.*, 1993
London	32.33	Barber and Bowsher, 2000; MOLA Centre for Human Bioarchaeology, 2009a; MOLA Centre for Human Bioarchaeology, 2009b
St. Albans	32.45	McKinley, 1992
Cirencester	34.67	McWhirr *et al.*, 1982

Table 4.4: Life expectancy at birth (*ex*) at York and comparative towns

The Romano-British towns considered in this study have overall life expectancy at birth ranging from approximately 24 to 35 years. York sits towards the higher end of this range. Likely life expectancy at birth in these samples is therefore slightly higher than previous estimations of approximately 20-30 years given for various parts of the Roman Empire (Hopkins, 1966: 263; Bagnall and Frier, 1994: 104; Scheidel, 2001a: 24). However, the results do fit more closely with adult life expectancy estimations proposed for Roman Britain by Brothwell (1972). Brothwell (1972: 86) suggests that such age calculations should only be undertaken using data for adult individuals, because of the inherent bias related to sub-adults in archaeological samples. This also allows life expectancy estimates to be made for each sex.

Furthermore, it should be noted that the estimates in Table 4.4 are all based on life table analysis of skeletal samples. As these are archaeological samples, it is highly likely that there is some under-representation in the sub-adult age categories. As a result of this, the differences in *ex* values could just be a reflection of variation in the amount of under-representation of infants and children, as opposed to reflecting genuine differences in life expectancy at birth, and mortality. If infants are under-represented skeletally, calculated life expectancy at birth will increase, as a result of mortality levels appearing to be lower in this age category. Increased life expectancy at birth in the York assemblage may therefore appear higher than the aforementioned estimations of 20-30 years by Hopkins (1966) and other authors, because the alternative age estimations were calculated using historical records (e.g. census data) with data presumably representative of the genuine age and mortality structure of the living population (Chamberlain, pers. comm.).

In view of this, adult life expectancy of males and females was calculated for York and each of the comparative assemblages, and compared with Brothwell's (1972: 83) estimates for Roman Britain (Tables 4.5 and 4.6). As only sexed adult individuals were used, life expectancy after the age of 15 was calculated. Total adult life expectancy is therefore the number of remaining years of life at 15 years, plus the 15 years that have already been lived.

Site	**Years of Life Remaining after 15yrs (*ex*)**	**Adult Male Life Expectancy**	**Reference**
York	21.22	36.22	This study
Gloucester	14.46	29.46	Simmonds *et al.*, 2008
Ancaster	17.44	32.44	Cox, 1989
Derby	17.89	32.89	Wheeler, 1985
Dunstable	18.84	33.84	Matthews, 1981
London	21.04	36.04	Barber and Bowsher, 2000; MOLA Centre for Human Bioarchaeology, 2009a; MOLA Centre for Human Bioarchaeology, 2009b
Colchester	21.87	36.87	Crummy *et al.*, 1993
Winchester	25.05	40.05	Clarke, 1979; Booth *et al.*, 2010
St. Albans	25.25	40.25	McKinley, 1992
Cirencester	26.94	41.94	McWhirr *et al.*, 1982
Dorchester	27.33	42.33	Farwell and Molleson, 1993; Davies *et al.*, 2002; Egging Dinwiddy, 2009
Brougham	27.88	42.88	Bell and Cool, 2003
Roman Britain	-	34.8	Brothwell, 1972: 83

Table 4.5: Adult male life expectancy (*ex*)

Site	**Years of Life Remaining after 15yrs (*ex*)**	**Adult Female Life Expectancy**	**Reference**
York	22.1	37.1	This study
Ancaster	13.05	28.05	Cox, 1989
Gloucester	14.5	29.5	Simmonds *et al.*, 2008
Derby	16.27	31.27	Wheeler, 1985
Dunstable	17.28	32.28	Matthews, 1981
Brougham	19.84	34.84	Bell and Cool, 2003
Winchester	20.3	35.3	Clarke, 1979; Booth *et al.*, 2010
London	21.29	36.29	Barber and Bowsher, 2000; MOLA Centre for Human Bioarchaeology, 2009a; MOLA Centre for Human Bioarchaeology, 2009b
Colchester	22.29	37.29	Crummy *et al.*, 1993
St. Albans	23.88	38.88	McKinley, 1992
Cirencester	23.94	38.94	McWhirr *et al.*, 1982
Dorchester	26.86	41.86	Farwell and Molleson, 1993; Davies *et al.*, 2002; Egging Dinwiddy, 2009
Roman Britain	-	31.9	Brothwell, 1972: 83

Table 4.6: Adult female life expectancy (*ex*)

It should be noted that Brothwell's Roman life expectancy estimates were based on data from 173 sexed, adult individuals from the Trentholme Drive assemblage (Brothwell, 1972: 82). Of these, 120 were male and 53 were female. However, for this study, comparison of age at death profiles were conducted for Trentholme Drive, firstly using data from the Wenham (1968) report, and secondly using data from the Peck (2009) study. Very little difference was found between the two profiles, suggesting that Brothwell's (1972) adult life expectancy estimates are largely accurate. Any discrepancies may relate to inaccurate sexing of individuals from Trentholme Drive, conducted during the original analysis by Wenham (1968).

As already stated, the sample used to calculate the Romano-British estimates by Brothwell (1972) was wholly taken from Wenham's (1968) Trentholme Drive data. Many of the samples used in life expectancy calculations for this study were significantly larger than the Trentholme Drive sample. Interestingly, of the populations that produced lower than average life expectancies, three (Ancaster, Gloucester and Derby) had sample sizes of less than 100 individuals. This evidence may, therefore, imply that the Trentholme Drive sample used in the calculation of Romano-British life expectancy figures may have produced lower estimates as a product of the sample size, especially in the female sample. As the new life expectancy estimates produced in the present project vastly outstrip Brothwell's sample in terms of size and inclusiveness, the Brothwell estimates are essentially nullified.

In the York population, adult female life expectancy is slightly higher than in males, by approximately one year. Of the comparative assemblages, the majority have higher male life expectancy; however like York, Colchester, Gloucester and London also have slightly higher female life expectancy. Of the eight populations where male life expectancy is longer, males live on average between one and eight years longer than females. Of the four populations where the reverse is true, females are likely to live less than one year longer than males. It appears that something is causing populations at York, Colchester, Gloucester and London to have male/female life expectancies that are more similar to each other, rather than males having elevated life expectancy. This will be discussed further in Chapter 5.

4.1.5. Spatial Density Analysis

The total size of the study area is 78.54km^2. Each site is represented by a marker proportional in size to the number of burials found at the site (Figure 4.14). It should be noted that these markers do not necessarily cover the entire location excavated; each marker is centred on the given site grid co-ordinate. Marker size merely serves to illustrate areas with higher/lower burial density.

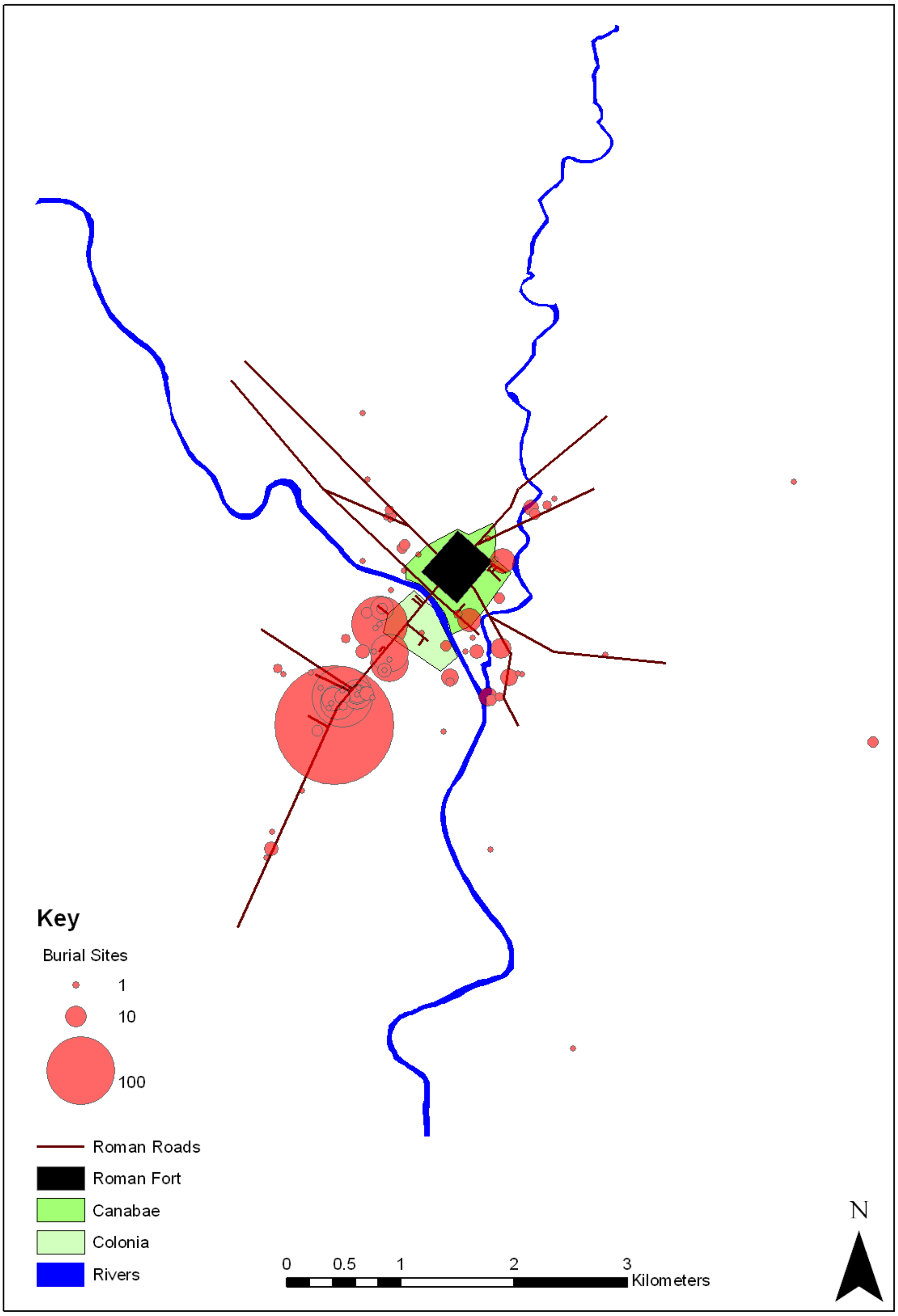

Figure 4.14: Proportional burial markers at all excavated sites for Roman York (this study). This figure does not include a marker that accurately represents the large number of burials excavated at the Railway cemetery (to the north west of the *colonia*) in the nineteenth century, as the vast majority of these were discarded and therefore not included in this study

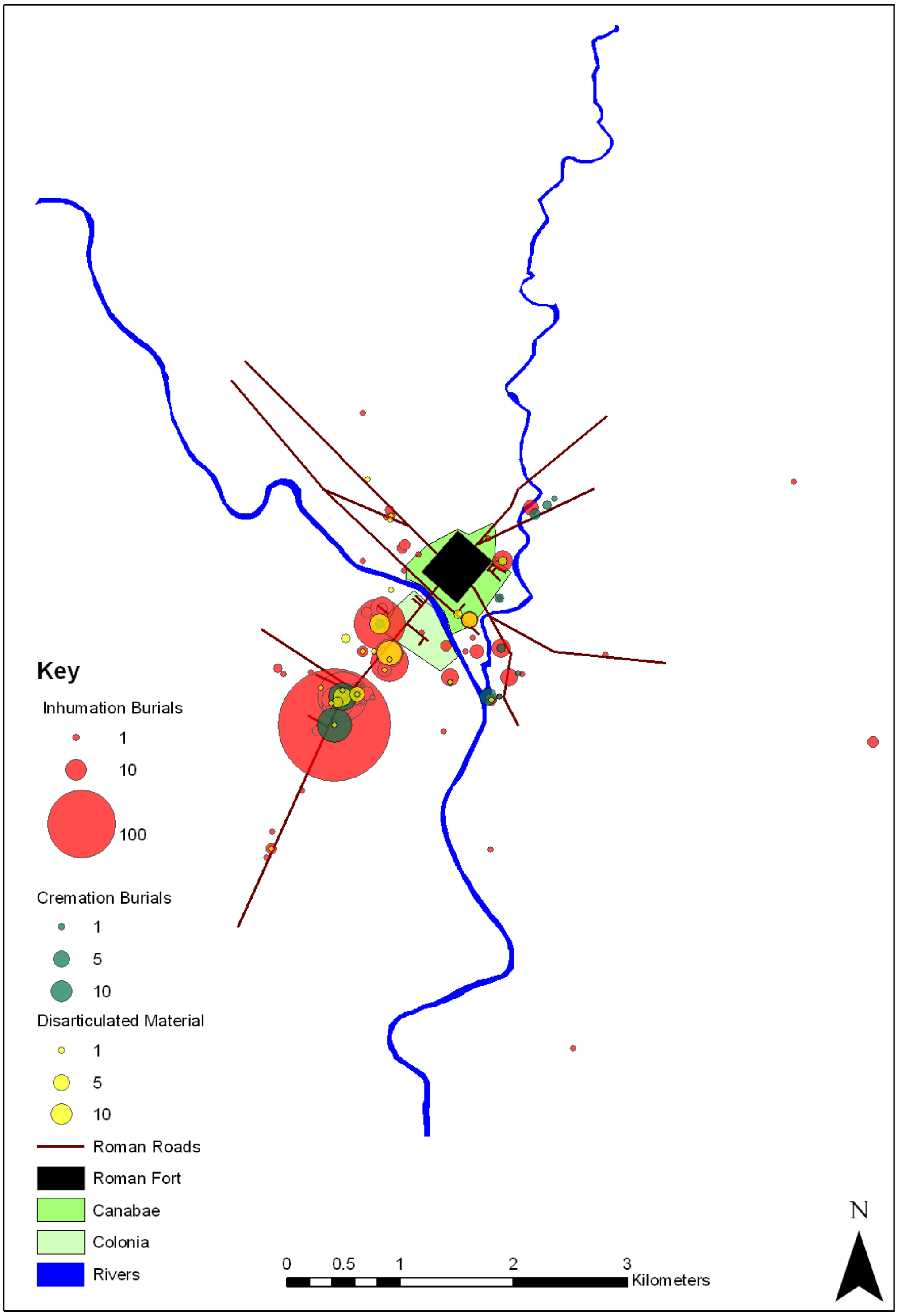

Figure 4.15: Proportional burial markers at all excavated sites for Roman York (this study), divided by burial type

As expected, burial sites cluster around the known Roman roads. Burials are concentrated in the south west, as demonstrated previously (Wenham, 1968; Ottaway, 2004). Overall, the majority of burials are located to the south of *Eboracum*, on the south west side of the River Ouse. The location of the extensive Railway cemetery, which could not be plotted due to lack of detailed information regarding population size also fits with this observation. Over 100 inhumation and cremation burials from this site are recorded in a small amount of detail in the 1968 Royal Commission report, and some of these individuals (retained at the Yorkshire Museum) are included in Figures 4.15 and 4.16. However, little information exists as to the exact location that these burials were found in, and the vast majority of the cemetery population was cleared and disposed of without recording of material.

Burial sites were re-plotted on the same map of *Eboracum*, this time divided by burial type, in order to see whether any differential distribution could be observed (Figure 4.16). Disarticulated material was also plotted, though it should be noted that most of this disarticulated material was unburnt and is, therefore, more likely to be associated with the inhumation burials. It is important to include unburnt disarticulated skeletal remains as this material is likely to be representative of inhumation burials that have undergone later disturbance.

The frequency of cremation burials is much lower than inhumation burials. This is likely to be at least partially the result of treatment of cremated material by archaeologists. Cremation burials were regarded as of little interest and importance to archaeologists until the mid-twentieth century, partly because of their fragmentary nature. This led to cremation burials seldom being retained in archaeological collections, unless they were associated with finds such as pottery or grave goods. Even in the twentieth century, cremation burials received poor treatment and little in the way of post-excavation analysis. For example, eleven unurned Roman cremations excavated at Riccall Shaft near Selby in 1977 were recorded and lifted during archaeological excavation (Turnbull, 1998), but these were discarded sometime between excavation of the site and the post-excavation analysis taking place. Similarly, research for this study has found that many cremation burials that were accessioned to museums in the twentieth century have simply been thrown away; very rarely the urns are kept but the cremated bone disposed of, presumably because of the assumption that the material was useless. This has led to this study being heavily biased towards inhumation burials. Similar attitudes have also led to a bias towards inhumation burials in study material from other time periods in Britain. For example, Squires (2011) doctoral study of cremation burials from early Anglo-Saxon cemeteries at Cleatham and Elsham in Lincolnshire found that late nineteenth and early twentieth century archaeologists discovering cremation burials were likely to discard the cremated bone, whilst retaining the cinerary urn/vessel and any small finds. Although Anglo-Saxon cremation burials are better represented from the 1970's onwards, in some instances the burned human skeletal material from a single cemetery will be curated at multiple museums around the country (Squires, pers. comm.). Despite the reduced number of cremation burials, it is still clear that cremated material was present in the majority of areas that contained inhumation burials, suggesting continued use of the same cemetery areas after the transition from cremation to inhumation burial in the third century.

The only notable exception to this is to the north west of *Eboracum*, where there was no cremated material, but unburnt material was observed at eleven sites. However, the Royal Commission on Historical Monuments (1962: 72-76) records an "extensive" cremation and inhumation cemetery in this area discovered in the seventeenth century, with burials of both kinds being observed during building and renovation projects (e.g. building of the York-Scarborough railway) well into the nineteenth century. Although a number of the burials discussed in this report are listed as being accessioned at the Yorkshire Museum, research conducted by the current Yorkshire Museum archaeological curators for this study did not find any of this material. It should therefore be assumed that, again, these remains have been discarded or lost.

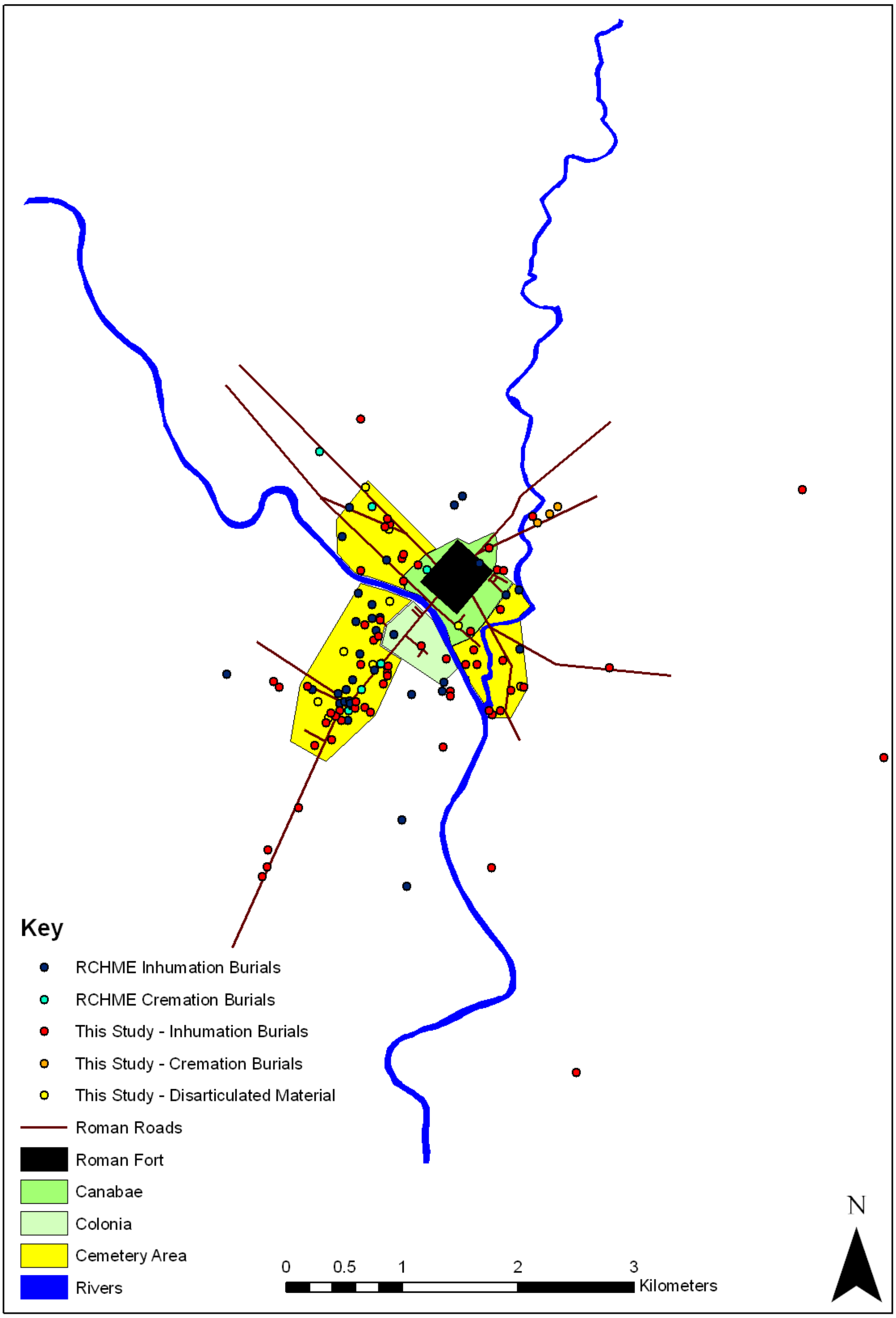

Figure 4.16: Proposed core burial areas

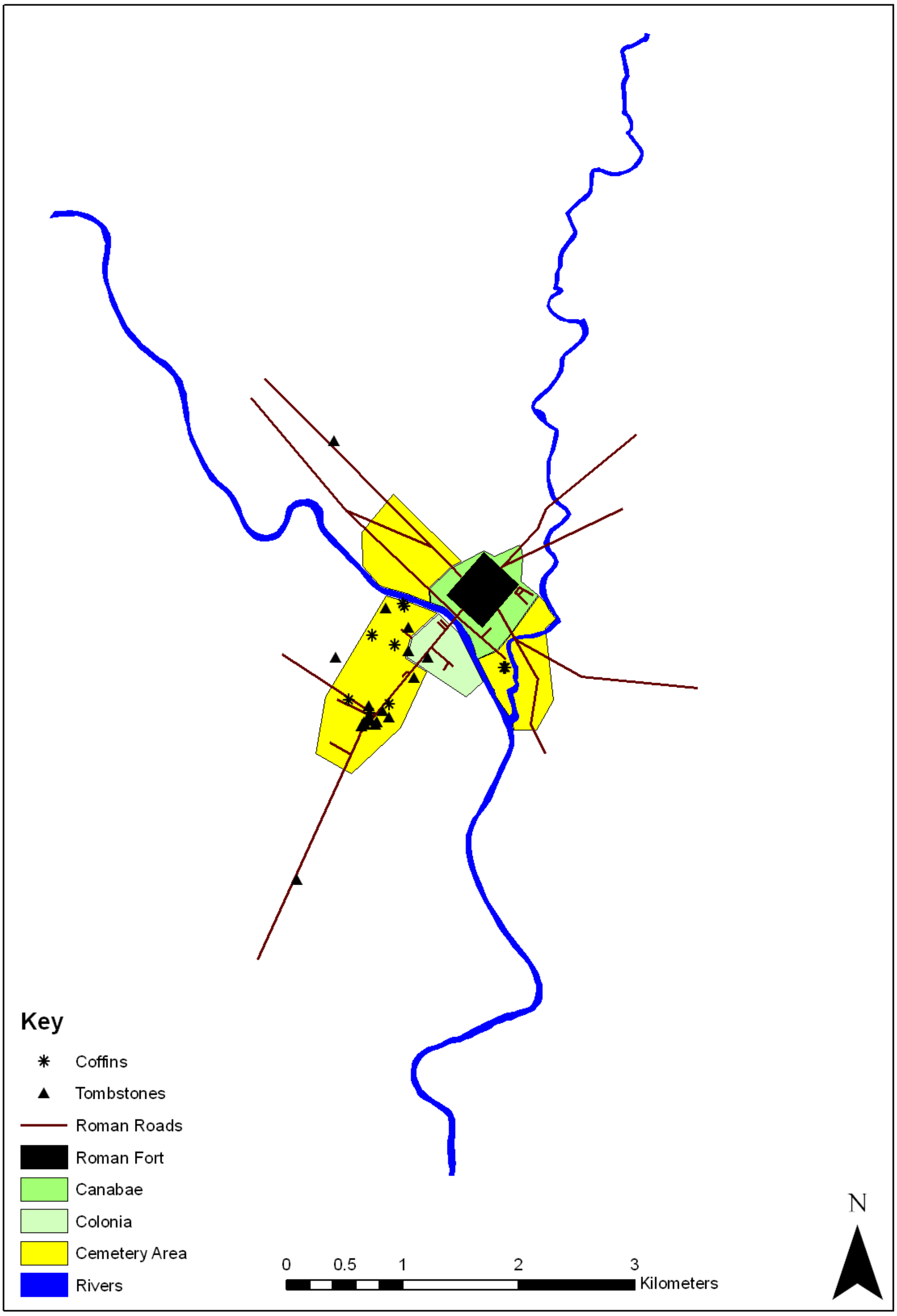

Figure 4.17: RCHME (1962) coffins and tombstone location plan and proposed core burial areas

All sites for this study, as well as extra sites yielding Roman burials and reported by the Royal Commission on Historical Monuments (1962) were plotted on the map of *Eboracum* in order to observe the spatial extent of cemetery areas in ArcGIS 9.3. The intention of this exercise is not to state that the areas marked out in Figure 4.16 constitute discrete, bounded cemeteries. Instead, these represent the known, core areas around *Eboracum* that appear to form the preferred areas of burial around the main roads. If the areas with the highest concentrations of burials represent preferential burial spots, Figures 4.14-4.16 would suggest that the most favoured burial region was in the south west, on the main road heading towards Tadcaster in North Yorkshire. Visually, the north west and south east burial regions appear very similar. Calculated burial density, however, shows that per square metre, it is the south east cemetery that has the next highest burial density (see Population Size section). Consequently, the north west region is the least preferential of these three burial regions, though presumably more preferential than the area to the north and north east of *Eboracum*, and other outlying areas.

In order to test this theory regarding burial location preference, find spot locations for tombstones and coffins from the Royal Commission on Historical Monuments (1962) were plotted on the map of *Eboracum* and the three cemetery regions in ArcGIS 9.3 (Figure 4.17). Figure 4.17 shows that the majority of tombstones and coffins are located in the area designated by this study as the main south west cemetery, with a particularly dense cluster located around The Mount and Dalton Terrace. Of the others, one tombstone falls just outside this area (in the area designated in the next section as the peripheral area of the south west cemetery); one tombstone is located on the southern part of the south west road at Dringhouses (in close proximity to a small cluster of burials visible in Figure 4.16); one tombstone is located on one of the main roads heading out of the north west cemetery; lastly, two coffins were found in very close proximity to each other within the south east cemetery.

This distribution pattern augments the theory that the south west cemetery was the preferred area of burial associated with *Eboracum*. The fact that the areas surrounding York have all undergone fairly extensive excavation indicates that this distribution is unlikely to be the result of excavation bias towards the south side of the city. Furthermore, many of the tombstones and coffins were found close to the main road, which suggests that they were bought and erected by/for people who could afford burial plots in prime locations. As discussed in Chapter

2, prime burial locations during the Roman period were generally close to the town, with the most sought after plots being located nearest to the town gate (Hope, 1997: 105). Presumably, plots situated directly on the main roads were also prized, as they would be easy to view by travellers entering and leaving the town. The concentration of burials, tombstones and coffins around the south west road may also suggest that this was the most frequented road in and out of *Eboracum*. These ideas will be discussed further in Chapter 5.

4.1.6. Population Size

As explained in Chapter 3, population size was estimated by multiplying the size of the settlement area of *Eboracum* by a constant of 127 persons per hectare, based on Richardson's (2000) estimation of population density in pre-industrial urban populations. The area of the fortress, *canabae*, and *colonia* were measured in ArcGIS 9.3. The resulting areas are presented in Table 4.7. As the fortress was situated within the *canabae*, the total area of the *canabae* in Table 4.7 does not include the amount of space occupied by the fortress.

Feature	**Area (m^2)**
Fortress	194,400
Canabae	308,631
Colonia	247,522
Total	**750,553**

Table 4.7: Total estimated area of *Eboracum*

Civilian and military populations will be considered here separately, for reasons discussed below. According to the table above, the *canabae* and *colonia* (considered here as the civilian areas rather than military) occupy a combined space of 556,153m^2, which equates to a total of 55.6153ha. When multiplied by the constant, these values give a population estimate of 7063.1431. Rounded to the nearest 10 individuals, this gives an approximate living civilian population of 7060 individuals.

As the population structure of the fortress would have been different from the population structure of the *canabae* and *colonia*, we must consider whether it is appropriate to apply the same constant of 127 individuals per hectare to the fortress population. Although the original study by Richardson (2000) proposed this population density in Roman military camps, the constant of 127 persons per hectare only produces a population of 2469 individuals for a fortress of the size given in Table 4.7. This figure falls short of most size estimations given for Roman legions. The exact size and composition of a Roman legion has been widely debated in the secondary literature, largely due to gaps in the available evidence. Mattingly (2007: 131) has suggested, based on a combination of archaeological and epigraphic evidence, that each of the four legions invading Britain in the first century comprised approximately 5500 men. Scheidel (1996: 121) suggests that one legion was comprised of 10 base cohorts of 480 men. These ten cohorts may also have been accompanied by a cavalry unit, comprising approximately 120 men (Rossi, 1971: 70; Roth, 1994: 353; Scheidel, 1996: 121). However, the organisation of the first cohort may have been different; evidence suggests that some time in the first century a decision was made to double the size of the first cohort (Frere, 1992: 210; Scheidel, 1996: 121; Brewer, 2002: 126). Despite evidence inferring that this would have been the case, Southern (2007: 101) has argued that it is unclear when this decision was made, when doubling of the first cohort would have taken effect, and also that not every legion would have adopted the double cohort policy.

In addition to these considerations regarding the size of the first cohort, it has been suggested that a legion may, or may not, be accompanied by a group of non-combatant individuals referred to by Livy as the *impedimenta* (Roth, 1994: 357). This group is likely to have comprised of slaves, and servants such as drivers and porters (Roth, 1999: ch. 2). There is also the potential for the presence of women and children associated with the legion, such as wives and families, concubines and prostitutes (Mattingly, 2007: 195). Roth (1994: 357) has postulated that this group of non-combatant army associates may have numbered up to 1200 individuals at any given time, though it is unclear what this figure is based on. Furthermore, it is unknown what proportion of this group may have lived in the fort or the surrounding *canabae*; indeed, some of these individuals may have lived in both areas, dividing their time between the two.

Another consideration to take into account in respect to the size of a legion regards strength. Just because a legion should contain a specific number of individuals on paper, it is likely that actual numbers of soldiers would have differed (Mattern, 1999: 82-3). Indeed, there may have been lengthy periods when legionary bases were at less than full strength, for reasons such as there being no impending campaigning or war, or because troops had been sent to perform other duties e.g. temporarily join another campaign (Mattingly, 2007: 131; 188). Bearing all these factors in mind, it is perhaps not appropriate to hypothesise a single figure to represent the number of individuals inhabiting the fortress at York. Therefore, a minimum, maximum and middling "standard" estimation was made. The minimum estimate is based on the approximate fortress population where the legion is below maximum strength and has no dependents. The "standard" estimation is based on an approximate fortress population where the legion is at maximum strength (including cavalry and a double first cohort) but has no dependents. The maximum estimation is based on an approximate fortress population where the legion is at maximum strength (including cavalry and a double first cohort) and has all dependents living in the fortress. Population density for the fortress at *Eboracum* was calculated per hectare for each of these estimations assuming the fortress at *Eboracum* measures 19.44 hectares, based on size estimates calculated previously in ArcGIS 9.3. Each population estimate was then added to the civilian settlement estimation of 7060 individuals. Figures for all these estimations are given in Table 4.8. It is also notable that the calculated number of people per hectare for this fortress population is much larger than the 127 proposed by Richardson (2000).

Population size was also estimated for *Eboracum* using the excavated burial data utilised for spatial density analysis in this study. All seven burial regions are shown in Figure 4.18. Tables 4.9-4.14 show the size of the excavated area at each archaeological site and number of excavated burials, according to region. Burial density (per m^2) was calculated for each region by dividing total number of burials by the excavated area (Table 4.15).

	Fortress Population	People per hectare	Total Population
Minimum	3000	154	10,060
Standard	5240	270	12,300
Maximum	7500	386	14,560

Table 4.8: Estimated population size range for *Eboracum*

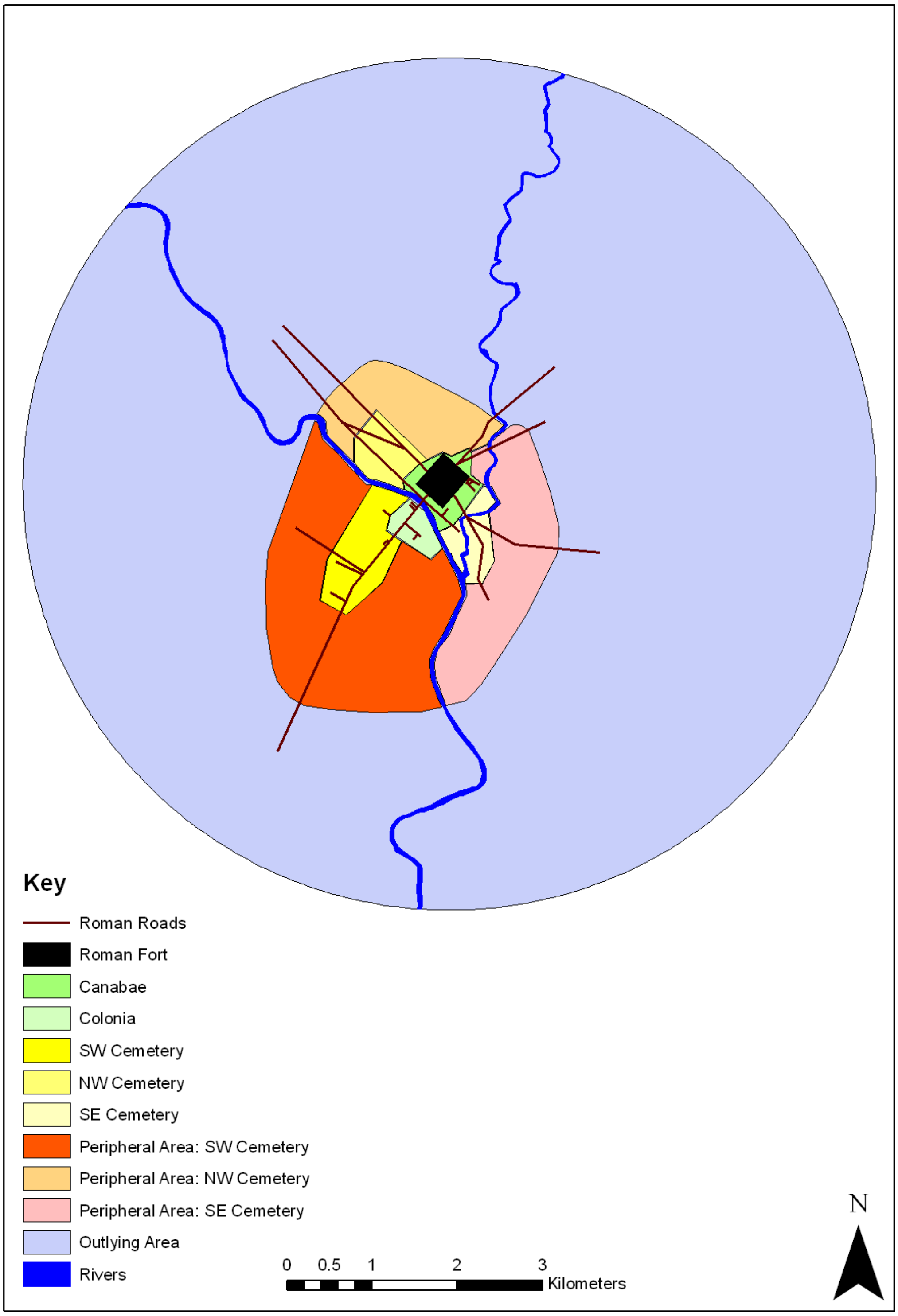

Figure 4.18: The seven burial regions utilised in spatial density analysis

Site	**Code**	**No. Burials**	**Excavated Area**
Former Foxton's Garage, Leeman Road, York	n/a	1x disarticulated	36m^2
IECC Compound, York Railway Station, York	SYO 385, EYO176, EYO 408	2x disarticulated	33.4m^2
14-20 Blossom Street, Fulford, York	1991/11, EHNMR 659465, SYO 226, EYO 16	1x disarticulated	44m^2
All Saints School, Nunnery Lane, York	YATGAZ 1993.15	1x disarticulated	12m^2
Moss Street Depot	YMD014, YMD04, SYO 1076	4x inhumations 1x disarticulated	792m^2
Mill Mount, The Mount, York	YMM04	2x cremations 6x disarticulated	816.125m^2
Mount School, Dalton Terrace, York	YORYM 2003.290, SYO 538	1x disarticulated	126.5m^2
The Mount School, Love Lane, York	YORYM 2000.501, SYO 675 EYO 469	1x disarticulated	952m^2
1-3 Driffield Terrace, York	YORYM 2004.354, SYO 556	53 inhumations 19x cremations 8x disarticulated	301m^2
6 Driffield Terrace, York	YORYM 2005.513, SYO 924	23x inhumations 1x cremation 3x disarticulated	33.48m^2
Elmbank Hotel, The Mount, York	OSA98EV02, 1998.13, SYO 320 EYO110	1x disarticulated	8m^2

Table 4.9: Number of burials and excavated area; SW Cemetery (continued on page 154)

Site	**Code**	**No. Burials**	**Excavated Area**
Trentholme Drive, York	MYO 2160, YORYM 1971: 303, EYO 2831-EYO 2833 MYO2169, 56612, NMR SE 55 SE 9, EYO 2824-EYO 2827?	283x inhumations 27x cremations 1x disarticulated	292.64m^2
Royal York Hotel, York	OSA99EX02, YORYM 1999.804 and YORYM 1999.940, EHNMR 1310194	16x inhumations	431m^2
All Saints School, Nunnery Lane, York	OSA02EX01	1x inhumation	2m^2
Mill Mount Extension, York	OSA01EV09	1x inhumation	249.75m^2
All Saints School, Mill Mount, York	1991/42, SYO 255, EYO 15	4x inhumations	69m^2
All Saints School, Mill Mount Lane, York	06004, SYO 1011	1x inhumation	220m^2
129 The Mount, York	YORAT 2006:25, SYO 1006	2x inhumations	74m^2
Total		**463**	**4456m^2**

Table 4.9: Number of burials and excavated area; SW Cemetery (continued from page 153)

Site	**Code**	**No. Burials**	**Excavated Area**
The White House, 10 Clifton, York	YORYM 2001.8437, SYO 778 EYO 573	2x inhumations	854m^2
18 Bootham Terrace, York	OSA06WB19	1x disarticulated	12.39m^2
33-34 St. Mary's, York	OSA08WB26	3x inhumations	220m^2
26-28 Marygate, York	1992.11	3x inhumations	90m^2
Total		**9**	**1167m^2**

Table 4.10: Number of burials and excavated area; NW Cemetery

Site	Code	No. Burials	Excavated Area
Former TVA Compound, Dundas Street, Hungate, York	HUN02, YHN03	2x cremations	98.75m^2
York Castle, York	58178, NMR SE 65 SW 16	4x inhumations	18m^2
The Barbican Centre, York	OSA03EV08	1x cremation	257.8m^2
The Barbican, York	OSA07EX02	7x inhumations	25m^2
Blue Bridge Lane, Fishergate, York	1994/, SYO 262 EYO 52	1x cremation	47m^2
Blue Bridge Lane, Fishergate House, York	YBB & YFH 00-04, SYO182	7x cremations	1594.58m^2
14-18 Malborough Grove, York	EYO 390, York Council 206	1x disarticulated	13m^2
Total		**23**	**2054.13m^2**

Table 4.11: Number of burials and excavated area; SE Cemetery

Site	Code	No. Burials	Excavated Area
Cherry Hill, Clementhorpe, York	1989.14, NMRMIC-2960	7x inhumations	36m^2
Former Starting Gate Pub, Tadcaster Road, York	YORYM 2003.303, EYO 299	3x inhumations 1x disarticulated	1580m^2
The Fox, Tadcaster Road, Dringhouses, York	YATGAZ 1997.70 YORYM, SYO 288, EYO 78	1x inhumation	41.2m^2
Total		**12**	**1657.2m^2**

Table 4.12: Number of burials and excavated area; SW Periphery

Site	Code	No. Burials	Excavated Area
18-20 St. Maurice's Road, York	OSA05EV04	1x inhumation	19.12m^2
Heworth Croft	HEW06, SYO 1041	2x cremations	685.48m^2
Heworth Croft	YHC04, SYO 866 (incorporates material from YHV04 SYO 534)	3x cremations	292.4m^2
Laurens Manor, Lawrence Street, York	YLM05, SYO 959	1x inhumation	250m^2
Total		**7**	**1247m^2**

Table 4.13: Number of burials and excavated area; SE Periphery

Site	Code	No. Burials	Excavated Area
Heslington East, York	HE08	1x inhumation	1580m^2
Heslington East, York	HE09	2x inhumations	1579m^2
Total		**3**	**3159m^2**

Table 4.14: Number of burials and excavated area; Outlying Area

Region	Excavated Area (m^2)	No. Burials	Burial Density (burials/m^2)
SW cemetery	4456	463	0.10390
NW cemetery	1176	9	0.00765
SE cemetery	2054	23	0.01120
SW peripheral	1657	12	0.00724
NW peripheral	-	-	0.00643
SE peripheral	1247	7	0.00561
Outlying	3159	3	0.00095

Table 4.15: Burial density per region

Region	Region Size (m^2)	Burial Density	Expected Dead
SW cemetery	172,320	0.10390	17,905
NW cemetery	444,094	0.00765	3,399
SE cemetery	385,482	0.01120	4,316
SW peripheral	4,285,311	0.00724	31,034
NW peripheral	1,386,595	0.00643	8,913
SE peripheral	2,263,512	0.00561	12,706
Outlying	68,201,712	0.00095	64,769
Total Expected Dead			**143,042**

Table 4.16: Expected number of dead per region

As stated in Chapter 3, the expected number of dead was then calculated for each region by multiplying the total region area by the appropriate burial density. Expected number of dead was also calculated for the Railway Station site (see pages 95-6 for methodology).This resulted in an estimated cemetery population of 17,436 at this site alone.

The expected number of dead for each region could then be added together to give the total number of dead for the full period of Romano-British occupation of *Eboracum*. These values are given in Table 4.16. Total expected dead was calculated at 143,042.

Following the calculation discussed in Chapter 3 (page 95), the maximum living population was then calculated as follows:

$$\frac{32.26 \text{ x } 143{,}042}{339} = 13{,}612$$

This calculation suggests that the maximum living population of *Eboracum* was approximately 13,600 individuals. This figure sits just over half way between the “standard” and maximum population estimates calculated according to settlement size and density.

All population size estimates for *Eboracum* generated by this study are larger than previous estimates discussed in Chapter 3. With regards to the military population, estimates from this study (Table 4.8, page 152) do approximate the 5000-6000 individuals postulated by previous authors (Jones, 1984: 41; Addyman, 1989: 246). However, the results of this study suggest that prior estimates regarding the civilian population fall short of the actual number. The (maximum) figure of 7060 civilian individuals based on settlement size is more than twice the number approximated previously. Similarly, population size estimation according to burial density at excavated sites suggests that prior population estimates may fall short. A high degree of confidence in these elevated population estimates is gained by the fact that both methods used in this study yielded similar results. It should also be noted that, due to the material and methods utilised in calculation of these population size estimates, the results are more likely to relate to the size of the population during the later period of occupation. This will be discussed in Chapter 5.

Once the number of Total Expected Dead was calculated, this was also divided by the number of years of Roman occupation of *Eboracum* (as given in Chapter 3; 339 years). This calculation gives a death rate of approximately 422 individuals per year, which equates to 3.1% of the maximum living population.

The 785 individuals in this study comprise 0.55% of the Total Expected Dead for *Eboracum*. If we include individuals recorded in the Royal Commission (1962) report but not available for this study (a further 390 individuals), the minimum number of excavated individuals still only comprises 0.82% of the Total Expected Dead. Even considering the unknown number of individuals excavated in antiquity (e.g. the “abundant” number of human bones observed in the motte at Clifford’s Tower in 1824 and 1902, and the two large pits containing “slave” burials at the Mount; RCHME, 1962: 69 and 79), this is a very small proportion of the total expected population for the period.

4.2. Diet

Of the 785 individuals examined in this study, a minimum of 260 are dentate. This figure comprises 249 individuals from discrete inhumation burials, one individual from a cremated burial and a minimum of 10 individuals from 35 disarticulated contexts. Data were compiled for a total of 4602 teeth, and 5987 tooth positions. Total number of teeth comprises 237 deciduous teeth and 4365 permanent teeth. Both crude prevalence (CPR) and true prevalence (TPR) was calculated for *Eboracum*. Where possible, prevalence rates have combined sub-adult and adult data. The inferences made from this data were compared with previous dietary findings from Roman York. This is discussed in Chapter 5.

4.2.1. Dental Calculus

In this chapter calculus accumulation will be discussed chiefly in relation to diet, and the possible dietary patterns that may be inferred by observed calculus prevalence, however, other contributory factors will be discussed where applicable in Chapter 5.

Table 4.17 shows crude prevalence (CPR) and true prevalence (TPR) of dental calculus in the York assemblage, other comparative populations, and the overall rates for Roman Britain, based on Roberts and Cox (2003).

	Total Dentate	Affected	CPR %	Total Teeth	Affected Teeth	TPR %	Reference
York	260	205	**78.85**	4602	2654	**57.67**	This study
Ancaster	327	141	**43.12**				Cox, 1989: 75
Cirencester	196	105	**53.57**				McWhirr *et al.*, 1982: 150
Dorchester	25	24	**96**				Egging Dinwiddy, 2009: 20
Gloucester				2597	1582	**60.92**	Simmonds *et al.*, 2008: 43-4, 47
London	99	90	**90.91**	2031	1678	**82.62**	Barber and Bowsher, 2000: 284 (TPR); MOLA Centre for Human Bioarchaeology, 2009a; MOLA Centre for Human Bioarchaeology, 2009b (CPR)
Winchester	232	63	**27.16**	4341	1645	**37.89**	Booth *et al.*, 2010: 395-7
Roman Britain	1794	481	**26.81**	3923	1702	**43.39**	Roberts and Cox, 2003: 132

Table 4.17: CPR and TPR of dental calculus at York, comparative towns and Roman Britain

Both crude prevalence (per person) and true prevalence (per tooth) of calculus at York is higher than average for the Romano-British period. A chi-square test was conducted to test TPR at York and across all observed towns. The chi-square value (χ=1190.09) was significant (p=<0.01), indicating that prevalence of dental calculus is significantly different from expected values. Further chi-square testing showed that all four towns with calculated TPR's were significantly different from expected rates (York χ=7.44, p=<0.01; Gloucester χ=28.64, p=<0.01; London χ=596.48, p=<0.01; Winchester χ=557.73, p=<0.01). TPR at York, Gloucester and London were significantly higher than expected. TPR at Winchester was significantly lower than expected. No significant difference in the CPR of calculus was found according to sex.

These rates indicate that the range of calculus prevalence during this period is large, a finding which is in agreement with previous assessments of calculus during the Roman period (Roberts and Cox, 2003: 132). The high CPR (i.e. the percentage of individuals with calculus) in conjunction with the mid range TPR (i.e. the percentage of teeth exhibiting calculus) in the York population shows that a high proportion of individuals at York exhibit calculus but these individuals do not necessarily present involvement of a large number of teeth. When examining the entire dentate population at York, we see an average of 10.21 teeth being affected by dental calculus per individual (2654 affected teeth divided by 260 dentate individuals). Only two of the comparative populations had the necessary data available to make the same calculation: average numbers of teeth affected by dental calculus per individual were 16.95 in London and 7.09 at Winchester. High levels of calculus in the East London population were explained as being the result of long term accumulation in an aging population (Barber and Bowsher, 2000: 284), although clinical studies have suggested that calculus accumulation does not significantly increase with age (White, 1997: 510).

Average rates of affected teeth per individual at York and Winchester, however, are much lower, and on average, individuals from these two populations have less than half of their dentition affected by dental calculus. Both of these populations contain high proportions of mid-older adults; in similar proportions to London (see Figures 4.8 and 4.10, pages 130 and 132 respectively). However, the average number of teeth affected by dental calculus per person is much lower. This may suggest that factors other than accumulation of calculus according to age are affecting levels of calculus formation. Levels of dental hygiene and dietary composition are two likely influences.

The fact that calculus presence in the York assemblage is relatively high in terms of both individuals affected and number of teeth affected suggests that even if oral hygiene is being practiced in this population, its success was limited. If the supposition is correct that calculus formation and prevalence is linked to consumption of carbohydrates, fat and protein, this may suggest that the diet of the York population, as well as the other urban populations present in Table 4.17 was rich in these food types.

4.2.2. Enamel Hypoplasia

Table 4.18 shows CPR and TPR of enamel hypoplasia in the York assemblage, other comparative populations, and the overall rates for Roman Britain.

	Total Dentate	**Affected**	**CPR %**	**Total Teeth**	**Affected Teeth**	**TPR %**	**Reference**
York	260	139	**53.46**	4602	697	**15.15**	This study
Ancaster	327	22	**6.73**				Cox, 1989: 65
Colchester	159	64	**40.25**				Crummy *et al.*, 1993: 88
Dorchester	25	13	**52**				Egging Dinwiddy, 2009: 22
Gloucester				1524	449	**29.46**	Simmonds *et al.*, 2008: 43, 47
London	99	77	**77.78**	2031	295	**14.52**	Barber and Bowsher, 2000: 284 (TPR); MOLA Centre for Human Bioarchaeology, 2009a; MOLA Centre for Human Bioarchaeology, 2009b (CPR)
St. Albans	88	4	**4.55**				McKinley, 1992
Winchester	232	66	**28.45**	4341	311	**7.16**	Booth *et al.*, 2010: 397-8
Roman Britain	2808	380	**13.53**	4796	437	**9.11**	Roberts and Cox, 2003: 140

Table 4.18: CPR and TPR of enamel hypoplasia at York, comparative towns and Roman Britain

Both CPR and TPR of enamel hypoplasia in the York population is higher than the calculated average for Roman Britain. A chi-square test was conducted to test TPR of enamel hypoplasia at York and across all observed populations. The chi-square value (χ=476.05) was significant (p=<0.01), indicating that prevalence of enamel hypoplasia is significantly different from expected values. Further chi-square testing showed that of the four populations with calculated TPR's, three were significantly different from expected rates: York (χ=4.85, p=0.03); Gloucester (χ=301.57, p=<0.01); and Winchester (χ=169.19, p=<0.01). York and Gloucester both had significantly higher rates of enamel hypoplasia, whilst

Winchester had significantly lower rates. These results are likely to reflect levels of childhood stress (which may be related to diet) and also disease load within these populations. No significant difference was found in crude prevalence of enamel hypoplasia according to sex.

4.2.3. Dental Caries

Table 4.19 shows CPR and TPR of dental caries in the York assemblage, other comparative populations, and the overall rates for Roman Britain. While CPR in the York assemblage is higher than average for Roman Britain, TPR is lower. Approximately a third of the population have low prevalence of dental caries (an average of 2.53 caries per affected person in York, compared to 3.1 caries per affected person for the whole of Roman Britain). York has the second lowest caries TPR out of all the populations examined.

	Total Dentate	**Affected**	**CPR %**	**Total Teeth**	**Affected Teeth**	**TPR %**	**Reference**
York	260	85	**32.69**	4602	215	**4.67**	This study
Ancaster	327	183	**55.96**				Cox, 1989: 71
Cirencester	196	79	**40.31**	3251	167	**5.14**	McWhirr *et al.*, 1982: 146-9
Colchester	164		**41**	3406	225	**6.61**	Crummy *et al.*, 1993: 82-3
Derby				663	70	**10.56**	Wheeler, 1985: 278
Dorchester	108	40	**37.04**	2178	109	**5.00**	Davies *et al.*, 2002: 152; Egging Dinwiddy, 2009: 21
Dunstable	82	46	**56.10**	1600	59	**3.69**	Matthews, 1981: 41
Gloucester				2646	214	**8.09**	Simmonds *et al.*, 2008: 43, 46-7
London	99	46	**46.46**	2031	168	**8.27**	Barber and Bowsher, 2000: 283 (TPR); MOLA Centre for Human Bioarchaeology, 2009a; MOLA Centre for Human Bioarchaeology, 2009b (CPR)
St. Albans	88	11	**12.50**	333	23	**6.91**	McKinley, 1992
Winchester	232	83	**35.78**	4341	226	**5.21**	Booth *et al.*, 2010: 395
Roman Britain	5046	702	**13.91**	29247	2179	**7.45**	Roberts and Cox, 2003: 131-2

Table 4.19: CPR and TPR of dental caries at York, comparative towns and Roman Britain

A chi-square test was conducted to test TPR of dental caries at York and across all observed populations. The chi-square value (χ=107.28) was significant (p=<0.01), indicating that prevalence of dental caries is significantly different from expected values. Further chi-square testing showed that York, Cirencester, Dunstable and Winchester all had significantly lower than expected TPR of dental caries (Table 4.20). TPR at Derby, Gloucester and London was significantly higher than expected. TPR at Colchester, Dorchester and St. Albans was not significantly different. No significant difference was found in CPR of dental caries according to sex.

Site	χ	p
York	16.42	<0.01
Cirencester	5.28	0.02
Derby	22.98	<0.01
Dunstable	16.27	<0.01
Gloucester	18.22	<0.01
London	16.70	<0.01
Winchester	6.07	0.01

Table 4.20: Significant chi-square tests for dental caries prevalence

It is generally agreed that the prevalence of dental caries in the Romano-British period was higher than in the preceding pre-Roman Iron Age, probably because of dietary change that incorporated more foodstuffs containing sucrose (e.g. wine, honey, dried fruit such as figs and dates, and cereals, Roberts and Cox, 2003: 131 and 134; Peck, 2009: 166-7). Average TPR of caries in the British Iron Age has been calculated at 2.9% with a range of 2.1% to 24.5% whereas TPR for the Roman period is 7.45% with a range of 3.1% to 64.5%; (Roberts and Cox, 2003: 101). The results provided in this study confirm that Roman caries rates are indeed higher than that of preceding centuries. Nevertheless there is considerable variability in rates of caries across Roman Britain, and prevalence in York is low for the period.

4.2.4. Ante-Mortem Tooth Loss

Table 4.21 shows CPR and TPR of ante-mortem tooth loss in the York assemblage, other comparative populations, and the overall rates for Roman

Britain. This table shows that CPR in the York assemblage is approximately double the CPR for Roman Britain. The TPR at York, however, is much lower. Table 4.21 also shows that York has the lowest rate of ante-mortem tooth loss out of all the populations considered in this study. A chi-square test was conducted to test TPR of ante-mortem tooth loss at York and across all observed populations. The chi-square value (χ=1050.90) was significant (p=<0.01), indicating that prevalence of ante-mortem tooth loss is significantly different from expected values. Further chi-square testing showed that the populations of York, Cirencester, Derby, Dorchester and Gloucester all had significantly lower than expected TPR (Table 4.22). The populations of Dunstable and Winchester had significantly higher than expected TPR. TPR at Colchester and St. Albans were not significantly different.

	Total Dentate	**Affected**	**CPR %**	**Tooth Positions**	**Affected Positions**	**TPR %**	**Reference**
York	260	77	**29.62**	5987	317	**5.29**	This study
Ancaster				3735		**15.55**	Cox, 1989: 77
Cirencester				4710	399	**8.47**	McWhirr *et al.*, 1982: 146-7
Colchester				3800	397	**10.45**	Crummy *et al.*, 1993: 80-1
Derby				828	60	**7.25**	Wheeler, 1985: 278
Dorchester	25	16	**64.00**	1954	263	**13.46**	Davies *et al.*, 2002: 152; Egging Dinwiddy, 2009: 21
Dunstable	82	49	**59.76**	2275	393	**17.27**	Matthews, 1981: 41
Gloucester				2703	149	**5.51**	Simmonds *et al.*, 2008: 44, 47
St. Albans	88	11	**12.50**	401	49	**12.22**	McKinley, 1992
Winchester	232	59	**25.43**	3631	871	**23.99**	Booth *et al.*, 2010: 397
Roman Britain	3319	481	**14.49**	35762	5042	**14.10**	Roberts and Cox, 2003: 135-6

Table 4.21: CPR and TPR of ante-mortem tooth loss at York, comparative towns and Roman Britain

Site	χ	p
York	194.83	<0.01
Cirencester	29.06	<0.01
Derby	11.50	<0.01
Dorchester	11.82	<0.01
Dunstable	94.39	<0.01
Gloucester	81.29	<0.01
Winchester	637.22	0.01

Table 4.22: Significant chi-square tests for ante-mortem tooth loss prevalence

As 317 teeth were lost from 77 individuals in the York population, average tooth loss was calculated at 4.11 teeth per affected individual. Of the 77 affected individuals, 25 individuals (32.47% of affected individuals, or 9.62% of all dentate individuals) had 5 or more teeth missing. This included one individual where all 16 teeth of the maxilla had been lost. Almost 10% of the dentate population had thus experienced excessive tooth loss.

The results of an additional chi-square test showed that there was a statistically significant difference in crude prevalence of ante-mortem tooth loss between males and females (χ=8.64, p=<0.01). Of the 25 individuals with excessive tooth loss, 15 were male (34.46% of affected males, 10.95% dentate males) and 10 were female (29.41% of affected females, 14.49% dentate females). This indicates that females are more likely to have excessive tooth loss, and if this is indicative of oral health, it may be inferred from this that females had slightly poorer oral health than males. What should also be taken into account is that, demographically, females from this population have a slightly older age at death profile than males, so higher rates of excessive ante-mortem tooth loss and poorer oral health in females may be age progressive. It should be noted at this point that females from York do not have higher rates of dental caries, which suggests that age at death is the affecting factor. This correlation with age is generally true for the assemblage as a whole. Of the 77 individuals with ante-mortem tooth loss, 47 (61.04%; 18.08% of all dentate individuals) were over 35 years of age. 16 (64%) of the individuals with five or more teeth missing were also over 35 years of age. This pattern also fits with evidence for dental caries; ante-mortem tooth loss is likely to occur as a result of dental caries, and dental caries is age progressive.

Observed low rates of dental caries are likely to be at least partially affected by ante-mortem tooth loss, as excessively decayed and carious teeth are likely to be lost.

All the evidence so far discussed suggests that prevalence of ante-mortem tooth loss is low within the York population, and that individuals are more likely to lose teeth as they get older. This is especially true for females. Although these observations are not statistically significant, they have been observed as a general trend. The number of teeth lost ante-mortem may contribute to the low prevalence of dental caries observed.

4.2.5. Periapical Cavities

Table 4.23 shows CPR and TPR of periapical cavities in the York assemblage, other comparative populations, and the overall rates for Roman Britain. Rates were calculated according to the number of tooth positions and the number of these affected. CPR of periapical cavities in the York assemblage is higher than the calculated average for the period, and TPR is lower. Crude and true prevalence rates at York suggest that less than one fifth of the population experienced a low frequency of periapical cavities. In the York assemblage, individuals had between zero and four periapical cavities. This gives a mean of 1.83 cavities per affected individual or 0.32 cavities per dentate individual with a standard deviation of 0.76. 19.71% of dentate males and 21.74% of dentate females had one or more cavities. 27 (58.70%) of the 46 affected individuals had three or more cavities, with 10 (21.74%) of these individuals having three or four cavities. Of the 10 individuals affected more severely, seven were male (5.11% of dentate males) and three were female (4.35% of dentate females). An additional chi-square test showed that male and female individuals were not differentially affected.

A chi-square test was conducted to test TPR of periapical cavities at York and across all observed populations. The chi-square value (χ=319.48) was significant (p=<0.01), indicating that true prevalence of periapical cavities is significantly different from expected values. Further chi-square testing showed that York, Cirencester, Colchester, Dunstable and Winchester all had significantly lower than expected TPR of periapical cavities (Table 4.24). Ancaster, Derby and St. Albans all had significantly higher than expected TPR. TPR at Dorchester and Gloucester was not significantly different. These results again imply that oral health in the Roman population of York was better than the average Romano-British urban population.

	Total Dentate	**Affected**	**CPR %**	**Tooth Positions**	**Affected Positions**	**TPR %**	**Reference**
York	260	46	**17.69**	5987	84	**1.40**	This study
Ancaster	327	154	**47.09**	3735	154	**4.12**	Cox, 1989: 74
Cirencester	196	37	**18.88**	4853	59	**1.22**	McWhirr *et al.*, 1982: 149
Colchester				3406	27	**0.79**	Crummy *et al.*, 1993: 84
Derby				653	24	**3.68**	Wheeler, 1985: 278
Dorchester	108	25	**23.15**	2267	51	**2.25**	Davies *et al.*, 2002: 152; Egging Dinwiddy, 2009: 21
Dunstable	82	11	**13.41**	2275	19	**0.84**	Matthews, 1981: 41
Gloucester				961	12	**1.25**	Simmonds *et al.*, 2008: 45, 47-8
London	99	18	**18.18**				MOLA Centre for Human Bioarchaeology, 2009a; MOLA Centre for Human Bioarchaeology, 2009b
St. Albans	88	13	**14.77**	401	25	**6.23**	McKinley, 1992
Winchester	232	27	**11.64**	4341	45	**1.04**	Booth *et al.*, 2010: 397
Roman Britain	3372	384	**11.39**	24995	970	**3.88**	Roberts and Cox, 2003: 136-7

Table 4.23: CPR and TPR of periapical cavities at York, comparative towns and Roman Britain

Site	χ	p
York	12.94	<0.01
Ancaster	78.35	<0.01
Cirencester	17.27	<0.01
Colchester	27.23	<0.01
Derby	8.39	<0.01
Dunstable	16.99	<0.01
St. Albans	34.50	<0.01
Winchester	22.66	<0.01

Table 4.24: Significant chi-square tests for periapical cavities prevalence

4.2.6. Periodontal Disease

Table 4.25 shows CPR periodontal disease in the York assemblage, other comparative populations, and the overall rates for Roman Britain. This table shows that the highest rate of periodontal disease observed in this study was observed in the York assemblage. The results suggest that around two thirds of the population of Roman York were affected by periodontal disease. This rate was only slightly higher than rates at St. Albans and London, but twice the average rate for Roman Britain. As with other dental conditions discussed in this chapter, the range of prevalence of periodontal disease in Britain during the Roman period is very large (Roberts and Cox, 2003: 137). Despite this, prevalence of periodontal disease at York does seem relatively high for the period. A chi-square test conducted in SPSS Statistics 19 showed that male and female individuals were not differentially affected.

	Total Dentate	Total Affected	CPR %	Reference
York	260	162	62.31	This study
Ancaster	327	22	6.73	Cox, 1989: 76
Colchester	159	9	5.66	Crummy *et al.*, 1993: 85
Little Keep, Dorchester	108	18	16.67	Egging Dinwiddy, 2009: 20
London	99	59	59.60	MOLA Centre for Human Bioarchaeology, 2009a; MOLA Centre for Human Bioarchaeology, 2009b
St. Albans	18	11	61.11	McKinley, 1992
Winchester	232	59	25.43	Booth *et al.*, 2010: 397
Roman Britain	2381	698	29.32	Roberts and Cox, 2003: 137

Table 4.25: CPR of periodontal disease at York, comparative towns and Roman Britain

A chi-square test was conducted to test CPR of periodontal disease at York and across all observed populations. The chi-square value (χ=329.09) was significant (p=<0.01), indicating that crude prevalence of periodontal disease is significantly different from expected values. Further chi-square testing showed that York, London and St. Albans all had significantly higher than expected CPR (Table 4.26). Ancaster, Colchester and Dorchester had significantly lower than expected CPR. CPR at Winchester was not significantly different.

Site	**χ**	**p**
York	148.64	<0.01
Ancaster	74.80	<0.01
Colchester	40.06	<0.01
Little Keep, Dorchester	7.16	0.01
London	47.94	<0.01
St. Albans	9.58	<0.01

Table 4.26: Significant chi-square tests for periodontal disease prevalence

If the results of clinical studies linking periodontal disease and insufficient nutritional intake are correct, then a large proportion of the population of Roman York are likely to have been deficient in nutrients such as vitamin C, calcium, and antioxidants. In terms of dietary intake, this may suggest that individuals were not consuming enough fruit, vegetables and whole grains, which are all good sources of vitamin C and antioxidants (Moynihan, 2012: 111). Insufficient calcium could also be the result of lower intake of vegetables.

This interpretation should be regarded cautiously – the relationship between periodontal disease and diet is likely to be a complex one; the aforementioned results merely suggest a broad pattern. This study does not take into account severity of periodontal disease, which will also have a bearing on the relationship with diet. Chapter 5 will consider these results in combination with other dental evidence from this study and other evidence of diet from Roman York in order to establish an overall dietary pattern for the population.

4.2.7. Coarseness of Diet

Student t-tests (one tailed, two-sample equal variance) were applied to mean ages from the aforementioned analysis. Results showed that mean age calculated using auricular surface scores were significantly higher than mean age calculated for the same individuals via dental occlusal wear (p = 0.02, >95% confidence). Mean age calculated using pubic symphysis scores were also significantly higher, but to a slightly lesser degree (p = 0.08, >90% confidence). These results strongly suggest that individuals in this skeletal sample are more likely to be estimated as younger when using dental occlusal wear as opposed to pelvic ageing methods.

So, how might this difference arise? Data used in this analysis were collected by more than one researcher. This suggests that the likelihood of one observer using a method incorrectly (i.e. over or under estimating age when using one of the methods) is reduced – all observers have produced a similar pattern of results. The methods themselves are well-established, tested, standard methods, but how does age estimation compare between the methods? A study of the use of multifactoral aging methods in skeletal samples suggested that between individual methods, dental wear is consistently the most accurate at skeletal aging (Lovejoy *et al.*, 1985: 11-12) while the auricular surface is more likely to overestimate age in younger individuals and underestimate age in older individuals (Schmitt, 2004; Igarashi *et al.*, 2005: 335). This suggests that dental wear is the more accurate of the aging methods used in the present study. Conversely, these results may show that individuals were consistently estimated as slightly younger using dental wear as a result of having a softer diet than expected (resulting in lower levels of occlusal wear). Considering the likely dietary staples for this population (beef and products containing spelt wheat, discussed in Chapter 5, pages 276-8), it is suggested here that the former of these two scenarios is more likely.

4.2.8. Summary

In summary, this section of the study provides new insights and confirms previous assumptions about dietary composition in Roman York. Evidence from prevalence of dental calculus suggests that the population may have been consuming a substantial amount of (non-fermentable) carbohydrates, fats and protein. Evidence from dental caries and ante-mortem tooth loss suggest that the population is eating lower levels of sugar, starch, and fermentable carbohydrates than other Romano-British populations. Evidence from periodontal disease prevalence may suggest that individuals were consuming less than adequate levels of (one or a combination of) vitamin C, calcium and antioxidants, although this supposition needs to be tested against periodontal disease severity in this population. In general, observed levels of dental caries, ante-mortem tooth loss and periapical cavities suggests that oral health is generally good, indicating that the majority of the population were likely to be experiencing low levels of periodontal disease. Evidence from prevalence of enamel hypoplasia may suggest that the population were experiencing low levels of stress during childhood, although this may be related to diet or a combination of alternatives. Although prevalence and severity of ante-mortem tooth loss was generally low, approximately 10% of the population had excessive tooth loss which may have facilitated dietary change. Social and economic factors (e.g. social status, wealth, food type and availability) are likely to have significant influence on what could replace these foodstuffs. The type, quantity and nutritional value of the substituting food would then impact upon the health status of each individual. Finally, evidence from dental occlusal wear tentatively suggests that the population may have had a softer, less abrasive diet.

The outcome of these findings indicates that poor dental health is likely to be (at least partially) the result of a poor diet. Individuals with poor oral health are more likely to lose teeth. The more teeth that are lost, the more nutritionally poor diet is likely to become. This in turn exacerbates the original problem. Thus, individuals with poor oral health and bad diets are more likely to have progressively worse oral health and diet. This is likely to lead to other systemic health problems: diabetes, cardiovascular disease and obesity are just a few of the problems that may arise (Sheiham *et al.*, 2001; Bawadi *et al.*, 2011). This relationship has been explored in numerous clinical studies; it is likely that this relationship was also in effect in past populations.

4.3. State of Health

This section will present and examine observed true and crude prevalence rates for non-dental pathological conditions in the York skeletal sample. Evidence for trauma, congenital conditions and developmental abnormalities, circulatory disorders, joint disease, infectious disease, metabolic disease, neoplastic conditions and several miscellaneous conditions was observed. No evidence for skeletal dysplasia (such as achondroplasia) was observed. Prevalence rates combine both sub-adult and adult data. Where possible, crude prevalence rates (CPR) were also compared to those from other comparative towns and Roman Britain. The inferences that can be made from these results are discussed in Chapter 5.

For the comparative assemblages discussed below, raw data were utilised where possible to calculate comparable prevalence rates. If raw data were not available, prevalence rates were quoted from the relevant reports. For some towns, data were not available; data tables shown in each section should be referred to in order to ascertain which reports comparative figures are derived from. Towns with zero prevalence are also included.

4.3.1. Trauma

This category of pathological condition includes evidence of craniofacial fracture, post-cranial fracture, dislocation, spondylolysis, and peri-mortem trauma.

4.3.1.1. Craniofacial Trauma

Twenty-two individuals in the York assemblage were observed with evidence of ante-mortem craniofacial trauma; five individuals exhibited nasal fractures (Figure 4.19) and 13 individuals exhibited evidence of healed depressed fractures (Figure 4.20). All observed trauma in this section was healed. The majority of affected individuals were male, and from sites located along Driffield Terrace on the south west side of York (16/22 individuals). Therefore, observed results are likely to be skewed towards individuals from this one burial area.

Figure 4.19: Healed nasal fracture. SK 1975.30A, 147 Newington Terrace (McIntyre, 2011)

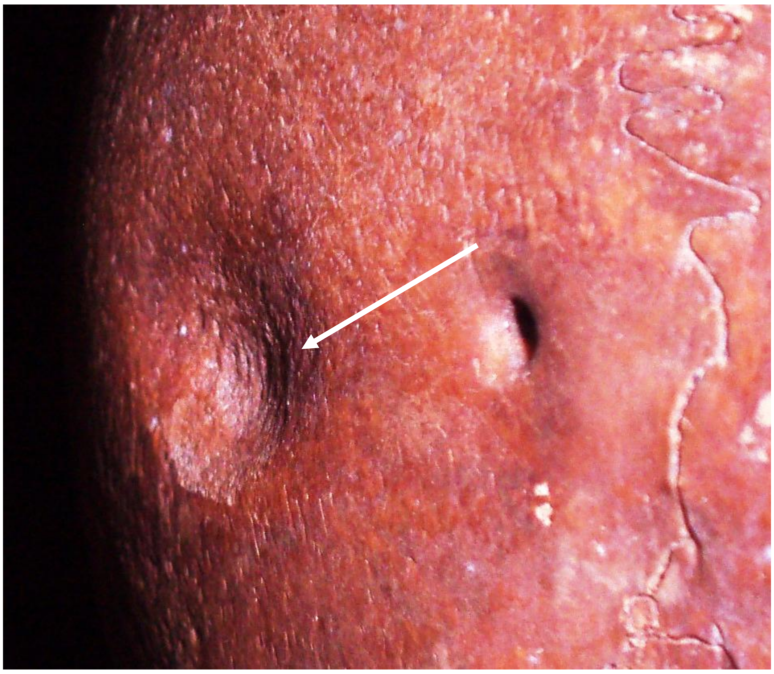

Figure 4.20: Healed depressed cranial fracture, left parietal. SK 34092, 16-22 Coppergate (McIntyre, 2011)

Table 4.27 shows true prevalence (TPR) of both these fracture types according to skeletal element.

Element	Total No. Individuals	Total Elements	Total Affected Elements	L	R	L TPR%	R TPR%	Total TPR%
Frontal	9	296.5	9					3.04
Parietal	6	603	6	4	2	1.35	0.67	1.00
Nasal	5	292	10	5	5	3.40	3.45	3.42
Maxilla	5	507	5	2	3	0.77	1.21	0.99

Table 4.27: TPR of craniofacial trauma per affected skeletal element

Table 4.27 shows that the most prevalent facial trauma was nasal fracture; approximately 3.4% of nasal bones from York have observable, healed fractures. Modern clinical studies have suggested that nasal fractures are one of the most commonly occurring facial fractures, and that they are most likely to be the result of interpersonal violence, with other common causes including traffic/motorised vehicular accidents, and falling (Alvi *et al.*, 2003; Erdmann *et al.*, 2008; and Lee *et al.*, 2010). With the exception of accidents involving motor vehicles, it is likely that these factors were similarly causative of nasal fractures in antiquity. The well healed depressed fractures observed in the sample (and located on the bones of the cranial vault) are likely to be the result of either accidental or intentional injury as a result of low velocity blunt force trauma (Lovell, 1997: 149-50).

Table 4.28 shows CPR of craniofacial trauma in the York assemblage, at comparative towns, and in Roman Britain. Differential recording strategies meant that CPR could not be broken down by element; therefore Table 4.28 shows general observed craniofacial trauma rates. Overall CPR of craniofacial trauma in the York assemblage is more than double the average for Roman Britain, and is also the highest observed rate in this study. A chi-square test was performed to examine craniofacial trauma prevalence according to sex in the York assemblage; the chi-square value (χ=9.27) was significant at the 95% confidence interval (p=0.02), indicating that craniofacial trauma is at a significantly higher rate in males than in females.

	Total No. Individuals	Total Affected	M	F	M CPR%	F CPR%	Total CPR%	Reference
York	785	22	21	1	7.14	0.64	2.80	This study
Ancaster	327	1					0.31	Cox, 1989: 45
Cirencester	424	5	5	0	2.04	0.00	1.18	McWhirr *et al.*, 1982: 161-172
Colchester	733	5	1	3	0.55	1.69	0.68	Crummy *et al.*, 1993: 8; 16; 33 and 76
Derby	112	0					0.00	Wheeler, 1985
Dorchester	1511	12	8	2	1.82	0.43	0.79	Farwell and Molleson, 1993: 199-205; Davies *et al.*, 2002: 152-3; Egging Dinwiddy, 2009: 23-5
Dunstable	112	0					0.00	Matthews, 1981
Gloucester	166	2	2	0	3.23	0.00	1.20	Simmonds *et al.*, 2008: 56, 64-5
East London	686	>1					0.15	Barber and Bowsher, 2000: 285
Winchester	783	10	7	2	3.27	0.92	1.28	Booth *et al.*, 2010: 365
Roman Britain	2083	24					1.15	Roberts and Cox, 2003: 153-4

Table 4.28: CPR of craniofacial trauma at York, comparative towns and Roman Britain

A Fisher's Exact test was performed to examine craniofacial trauma prevalence across all observed towns, with significant results (Fisher's Exact=20.20, p=<0.01). When the Fisher's Exact test was performed a second time, with the York data excluded, observed CPR of craniofacial trauma across all comparative sites was not significantly different from expected values (Fisher's Exact=4.47, p=0.66). It is therefore clear that the data from York skewed the results of the first test. This is also illustrated by Figure 4.26 (page 195), where York is observable as a clear outlier, indicating that rates of craniofacial trauma are substantially higher at York than in other comparative sites in this study.

As many of the affected individuals are from sites along Driffield Terrace, it is highly likely that overall craniofacial trauma prevalence for the town is being skewed by data from this one burial area. A chi-square test was performed to examine prevalence of craniofacial trauma at Driffield Terrace compared to all other burial locations. The chi-square value (χ=79.296) was significant at the 95% confidence interval (p=<0.01), suggesting that there is a significant difference in prevalence of craniofacial trauma between Driffield Terrace and all other sites. Some of this difference may be due to the high levels of skeletal completeness at sites along Driffield Terrace: inhumation burials from the three main Driffield sites (1-3, 2-4 and 6 Driffield Terrace: Field Archaeology Specialists, 2003b; Hunter-Mann, 2005; Ottaway, 2005) make up approximately 12% of the unburnt assemblage from York (n=82/663 inhumation burials). However, the number of cranial and facial bones recovered from these three sites constitutes a higher proportion of the total number of recovered cranial and facial bones (Table 4.29).

Element	Total Sample Size	No. From Driffield Sites	% From DriffieldSites	No. From All Other Sites	% From All Other Sites	Chi-Square	P-Value
Frontal	277	54.5	**19.7**	222	**80**	**28.90**	**<0.01**
L. Parietal	289	53.5	**18.5**	235	**81.1**	**25.67**	**<0.01**
R. Parietal	294	53.5	**18.2**	240	**81.5**	**24.15**	**<0.01**
L. Nasal	143	43	**30.1**	99	**69.2**	**56.14**	**<0.01**
R. Nasal	141	44	**31.2**	96	**68.1**	**61.37**	**<0.01**
L. Maxilla	251	53	**21.2**	197	**78.4**	**28.76**	**<0.01**
R. Maxilla	240	51.5	**21.5**	188	**78.1**	**34.43**	**<0.01**

Table 4.29: Number and proportion of craniofacial skeletal elements from York located at Driffield Terrace vs. all other burial locations in York

Table 4.29 indicates that of the seven craniofacial skeletal elements affected by ante-mortem trauma, approximately 20-30% of each sample derive from Driffield Terrace (c.f. the same three sites constituting 12% of the total number of individuals). The figures presented in Table 4.29 were subjected to chi-square tests, in order to ascertain whether there was any significant difference between recovery/preservation of craniofacial skeletal elements at Driffield Terrace compared to all other excavated sites in York. The results of these tests are also shown in Table 4.29. All test results were statistically significant at the 95% confidence interval (where $p=<0.05$), indicating that there are differential rates of preservation/recovery of craniofacial skeletal elements between Driffield Terrace and all other sites in York.

As the test results listed in Table 4.29 detect a significant difference in preservation/recovery rates of craniofacial skeletal elements, but do not indicate which direction this bias lies, a series of proportional bar graphs were constructed to ascertain the direction of bias. Proportionally, skeletons from Driffield Terrace are more likely have the cranial elements listed in Table 4.29, compared to skeletons from all other sites in York (also illustrated by a series of proportional bar graphs presented in Appendix 3). This suggests that there is preferential recovery of these cranial skeletal elements at Driffield Terrace.

Fisher's Exact tests were conducted to ascertain whether craniofacial trauma prevalence was still significant at Driffield Terrace (c.f. all other sites in York), in view of the fact that the aforementioned bones of the skull had higher recovery rates at Driffield Terrace. The presence/absence of trauma was tested for each bone in each of the two designated burial areas (excluding individuals when the relevant bone was not present). As the traumatic bone samples were very small, the Continuity Correction value was calculated. Significant results were found for the frontal (Continuity Correction=9.76, $p=<0.01$), right parietal (Continuity Correction=4.07, $p=0.04$) and right maxilla (Continuity Correction=6.83, $p=<0.01$). Significant results were not found for the left parietal, left maxilla, or either of the nasal bones. These results suggest that prevalence of craniofacial trauma at Driffield Terrace is significantly elevated compared to all oither sites in York, but only in the frontal, right parietal and right maxilla. Seemingly elevated rates of craniofacial trauma in the left parietal, left maxilla and left and right nasal bones may be the result of preservation/recovery bias at sites on Driffield Terrace.

4.3.1.2. Post-Cranial Trauma

Table 4.30 shows the frequency and distribution of post-cranial fracture in the York assemblage according to element. Sixty-four individuals provided evidence for a total of 112 traumatic injuries (e.g. Figures 4.21 and 4.22). Furthermore, over half the number of individuals with observed post-cranial trauma were again from sites at Driffield Terrace (38/64 individuals). Affected individuals had between one and four traumatic injuries to the post-cranial skeleton. The total number of elements incorporates inventoried skeletal elements from inhumations and disarticulated material. Total TPR also includes all unsided skeletal elements where necessary. Prevalence in all other post-cranial elements is 0%.

Table 4.30 shows that ribs were the most frequently fractured in the York assemblage, but the most prevalently injured elements were the intermediate and distal phalanges of the toes. Seven of the injuries involving the lesser toes (in six individuals) have resulted in ankylosis at the interphalangeal joint of the lesser toes (fourth or fifth digits). While ankylosis may not always be traumatic (e.g. it can be congenital or associated with infective or joint disease), these individuals do not show any evidence of another pathological condition (e.g. osteophytosis).

Figure 4.21: Healed double fracture to the left ulna. NHM 152 Wenham 95, Trentholme Drive (McIntyre, 2011)

Figure 4.22: Healed fracture to the left tibia. SK 2333, Shearsmith's building, Lion and Lamb car park, Blossom Street (McIntyre, 2011)

Element	Affected Individuals	Total Elements	Total Traumas	L	R	Unsided	L TPR %	R TPR %	Total TPR %
Manubrium	1	82	1						1.22
Ribs	16	2957	22	8	7	7	0.54	0.50	0.74
T4	2	142	2						1.41
T5	1	145	1						0.69
T6	1	146	1						0.68
T11	1	141	1						0.71
L2	4	148	4						2.70
L3	2	147	2						1.36
L4	2	152	2						1.32
Vertebrae (overall)	9	3418	13						0.38
Clavicle	5	477	5	3	2		1.22	0.86	1.05
Humerus	1	565	1	0	1	0	0.00	0.31	0.18
Scapula	2	311	2	2	0		1.38	0.00	0.64
Ulna	4	595	6	2	4		0.69	1.35	1.01
Radius	7	599	7	4	2	1	1.30	0.68	1.17
Carpals	2	830	2	1	1		0.25	0.23	0.24
Metacarpals	5	1109	6	1	5		0.19	0.86	0.54
Proximal hand phalanx	2	874	2	1	1		0.25	0.23	0.23
Distal hand phalanx	1	294	1	0	0	1			0.34
Femur	2	736	2	1	1		0.28	0.29	0.27
Tibia	4	592	4	2	2		0.67	0.72	0.68
Fibula	5	494	5	4	1		1.77	0.42	1.01
Tarsals	8	1186	8	3	5		0.52	0.83	0.67
Proximal foot phalanx	4	532	4	0	4		0.00	1.59	0.75
Intermediate foot phalanx	5	87	6	1	4	1	2.33	9.30	6.90
Distal foot phalanx	8	98	9	2	5	1	4.44	10.00	9.18

Table 4.30: TPR of post-cranial trauma per affected skeletal element

	Total No. Individuals	Total Affected Individuals	M	F	M CPR%	F CPR%	Total CPR%	Reference
York	785	63	49	5	16.67	3.21	8.03	This study
Ancaster	327	23	17	5	13.18	6.02	7.03	Cox, 1989: 45
Cirencester	424	59	51	7	20.82	7.00	13.92	McWhirr *et al.*, 1982: 161-72
Colchester	733	33	15	10	8.29	5.65	4.50	Crummy *et al.*, 1993: 75-6
Derby	112	2	2	0	10.53	0.00	1.79	Wheeler, 1985: 277
Dorchester	1511	57	34	12	7.73	2.58	3.77	Farwell and Molleson, 1993: 199-205; Davies *et al.*, 2002L 152-3; Egging Dinwiddy, 2009: 23-5
Dunstable	112	7	5	1	10.87	2.38	6.25	Matthews, 1981: 37-8
Gloucester	166	16	10	0	16.13	0.00	9.64	Simmonds *et al.*, 2008: 55; 64
Winchester	783	33	18	10			4.21	Booth *et al.*, 2010: 365

Table 4.31: CPR of post-cranial trauma at York and comparative towns

Table 4.31 shows CPR of post-cranial fractures in the York assemblage, and at comparative towns. Crude post-cranial trauma prevalence in the above urban populations ranges between 1.79% and 13.92%. With a CPR of 8.03%, the York assemblage sits right in the middle of this distribution. A chi-square test was performed to examine post-cranial trauma prevalence across all observed towns. The chi-square value (χ=82.52) was significant (p=<0.01), indicating that prevalence of post-cranial trauma at the above sites is significantly different from expected values. However, even when York is excluded and the same chi-square test is run (just to include all comparative sites), the result is still highly significant (χ=76.24, p=<0.01). Further chi-square testing showed that significant differences in observed and expected post-cranial trauma prevalence were observed at sites presented in Table 4.32. Significant differences were not found in the Ancaster, Colchester, Derby, or Dunstable assemblages.

Site	χ	p
York	6.46	<0.01
Cirencester	49.28	<0.01
Dorchester	12.47	<0.01
Gloucester	4.21	0.04
Winchester	3.96	0.04

Table 4.32: Significant chi-square tests for post-cranial trauma prevalence

These results indicate that there is a large range of post-cranial trauma prevalence in the observed populations, with approximately half having either significantly more or less post-cranial trauma than expected. Prevalence of post-cranial trauma in Roman York was significantly higher than expected. A further chi-square test was performed to examine trauma prevalence according to sex in the York assemblage. The chi-square value (χ=17.85) was significant (p=<0.01), indicating that York males had significantly more post-cranial traumatic injuries than females. This is consistent with the above findings for cranial trauma.

As with craniofacial trauma, many of the affected individuals are from Driffield Terrace. A third chi-square test was performed to examine prevalence of post-cranial trauma at Driffield Terrace compared to all other burial locations. The chi-square value (χ=151.87) was significant (p=<0.01), suggesting that there is a substantial difference in prevalence of post-cranial trauma between Driffield Terrace and all other sites. Further chi-square testing was conducted in order to ascertain whether the significant difference in rates of post-cranial trauma between Driffield Terrace and all other burial locations in York could be correlated with preservation/recovery bias of the affected skeletal elements (Table 4.33). Table 4.33 shows the number and proportion of unburnt skeletal elements recovered from Driffield Terrace compared to all other sites in York. The distal hand phalanges were not included in the tested skeletal elements, as the traumatic example could not be sided. All test results were significant, indicating that there are differential rates of preservation/recovery of post-cranial skeletal elements between Driffield Terrace and all other sites in York.

Element	Total Sample Size	No. From Driffield Sites	% From Driffield Sites	No. From All Other Sites	% From All Other Sites	Chi-Square	P-Value
Manubrium	82	38	**46.3**	44	**53.7**	97.74	<0.01
L Ribs	1435	607	**42.3**	819	**57.1**	133.62	<0.01
R Ribs	1361	582	**42.8**	768	**56.4**	138.37	<0.01
T4	141	58	**41.3**	83	**58.7**	124.57	<0.01
T5	144	58.5	**40.8**	84	**58.5**	125.49	<0.01
T6	145	59	**40.8**	84.5	**58.5**	124.15	<0.01
T11	139	60	**43.3**	77.5	**56**	140.26	<0.01
L2	147	59.5	**40.6**	86	**58.7**	134.53	<0.01
L3	145	60	**41.4**	84	**57.9**	137.36	<0.01
L4	150	60	**40**	89	**59.3**	131.77	<0.01
L Clavicle	233	58.5	**25.2**	174	**74.9**	52.16	<0.01
R Clavicle	223	60.5	**27.2**	161	**72.4**	70.69	<0.01
R Humerus	293	61	**20.8**	231	**78.8**	33.64	<0.01
L Scapula	134	58.5	**43.7**	75.5	**56.3**	125.49	<0.01
L Ulna	271	63	**23.3**	207.5	**76.7**	45.62	<0.01
R Ulna	284	63	**22.2**	220	**77.5**	42.89	<0.01
L Radius	286	63	**22.1**	222.5	**77.9**	41.69	<0.01
R Radius	271	61.5	**22.7**	208	**76.9**	45.19	<0.01
L Carpals	393	247	**62.4**	146	**37.2**	159.81	<0.01
R Carpals	430	267	**62.1**	157	**36.5**	208.49	<0.01
L Metacarpals	515	265	**51.5**	250	**48.5**	141.46	<0.01
R Metacarpals	566	290	**51.2**	271	**47.9**	160.33	<0.01
L proximal hand phalanx	400	243	**60.8**	154	**38.5**	201.61	<0.01
R Proximal hand phalanx	431	249	**57.8**	180	**41.8**	209.01	<0.01
L Femur	315	64.5	**20.5**	249	**79.2**	40.09	<0.01
R Femur	310	61.5	**19.8**	247.5	**79.8**	31.90	<0.01
L Tibia	272	62	**22.8**	209	**76.8**	42.05	<0.01
R Tibia	259	58.5	**22.6**	199	**77**	37.11	<0.01
L Fibula	219	60	**27.5**	157.5	**72.1**	59.45	<0.01
R Fibula	228	58	**25.4**	169	**74.1**	51.03	<0.01
L Tarsals	569	310	**54.5**	253	**44.5**	145.89	<0.01
R Tarsals	584	309	**52.9**	268	**45.9**	142.70	<0.01
R Proximal foot phalanx	251	153	**61**	95	**37.8**	168.58	<0.01
L Intermediate foot phalanx	43	32	**74.4**	9	**20.9**	125.39	<0.01
R Intermediate foot phalanx	43	31	**72.1**	11	**25.6**	119.86	<0.01
L Distal foot phalanx	45	36	**80**	8	**17.8**	138.64	<0.01
R Distal foot phalanx	50	33	**66**	16	**32**	92.00	<0.01

Table 4.33: Proportion of post-cranial skeletal elements present at burial locations on Driffield Terrace vs. all other burial locations in York

The test results listed in Table 4.33 detect a significant difference in preservation/recovery rates of post-cranial skeletal elements between burial locations, but do not indicate which direction this bias lies. Therefore, a series of proportional bar graphs were constructed to ascertain the direction of bias (presented in Appendix 4). These figures illustrate that a higher proportion of skeletons from burial locations on Driffield Terrace have the skeletal elements listed in Table 4.33, when compared to skeletons all other sites in York. This suggests that there is preferential recovery of all these skeletal elements at Driffield Terrace. It should particularly be noted that recovery of small bones of the extremities, e.g. from the hands and feet, is especially high at sites from Driffield Terrace. High recovery rates of these bones suggests that either preservation of skeletons in the Driffield Terrace area is much better (e.g. due to fewer post-depositional disturbances, burial environment more condusive to survival of smaller bones), and/or that the excavation strategy employed at Driffield Terrace was more thorough, with the archaeologists employing excavation techniques that would have a higher success rate in recovering smaller or more fragile skeletal elements.

Fisher’s Exact tests were conducted to ascertain whether postcranial trauma prevalence was still significant at Driffield Terrace (c.f. all other sites in York), in view of the fact that the aforementioned post-cranial bones had higher recovery rates at Driffield Terrace. The presence/absence of trauma was tested for each bone in each of the two designated burial areas (excluding individuals when the relevant bone was not present). As the traumatic bone samples were very small, the Continuity Correction value was calculated. Significant results were found for the right ribs (Continuity Correction=4.00, p=0.05), second lumbar vertebra (Continuity Correction=4.04, p=0.04), right metacarpals (Continuity Correction=4.76, p=0.03), and right tarsals (Continuity Correction=4.72, p=0.03). Significant results were not found for any other post-cranial skeletal elements. These results suggest that prevalence of trauma to the right ribs, second lumbar vertebra, right metacarpals and right tarsals is significantly elevated at Driffield Terrace compared to all other sites in York. Seemingly elevated rates of trauma in in other post-cranial skeletal elements are therefore likely to be the result of preservation/recovery bias at sites on Driffield Terrace.

4.3.1.3. Dislocation

Two (possible) dislocations were found in the York assemblage, both in adult male individuals. Both are considered as possible examples; there is insufficient osteological evidence to conclusively confirm either diagnosis (Field Archaeology Specialists 2005: Lx; Tucker, 2005). Furthemore, neither of these examples was available for examination by the present author. Both incidences have been considered traumatic rather than the result of alternative aetiologies (congenital, dysplasia etc.). Table 4.34 shows TPR of dislocation per joint. TPR at the elbow joint is based on the total number of distal humeri present; TPR at the hip is based on the number of ilia present. Prevalence in all other joints is 0%.

Joint	Total Joints	Total Affected	L	R	L TPR%	R TPR%	Total TPR%
Elbow	656	1	0	1	0.00	0.31	0.15
Hip	384	1	1	0	0.53	0.00	0.26

Table 4.34: TPR of dislocation per affected joint

The figures presented in Table 4.34 are unlikely to represent the prevalence rates for all dislocated joints in the York population, only those that were not treated or not treated successfully. Successfully realigned dislocations leave little or no skeletal evidence, and are thus archaeologically invisible (Roberts and Cox, 2003: 237). With elbow dislocation, some traumatic event is required to destabilise the elbow joint. The elbow is an extremely stable joint, so dislocation requires that more than one element of the elbow structure is disrupted (Ring and Jupiter, 1998: 568). Thus, the joint becomes more unstable as more elements are involved. Hip dislocations are a relatively rare traumatic injury; the hip joint is a highly stabilised joint, due to the presence of substantial surrounding ligamentous, capsular and muscular structures (Gaebler and McQueen, 2009: 1533-35; Obakponovwe *et al.*, 2011: 214). The hip can only be dislocated by considerable force, so associated injuries such as femoral fractures are common (Gaebler and McQueen, 2009; Obakponovwe *et al.*, 2011: 221). The hip is one of the joints most commonly affected by dislocation in the archaeological record, although this may also be the result of congential dislocation resulting from the joint being more unstable during early life/birth trauma (Roberts and Manchester, 1995: 87; Mitchell and Redfern, 2008).

	Total No. Individuals	Total Dislocations	M	F	M CPR%	F CPR%	Total CPR%	Reference
York	785	2	2	0	0.68	0.00	0.25	This study
Ancaster	327	0	0	0	0.00	0.00	0.00	Cox, 1989
Cirencester	424	0	0	0	0.00	0.00	0.00	McWhirr *et al.*, 1982: 175-7
Colchester	733	0	0	0	0.00	0.00	0.00	Crummy *et al.*, 1993
Derby	112	0	0	0	0.00	0.00	0.00	Wheeler, 1985
Dorchester	1511	3	3	0	0.68	0.00	0.20	Farwell and Molleson, 1993: 188-9; Davies *et al.*, 2002; Egging Dinwiddy, 2009
Dunstable	112	0	0	0	0.00	0.00	0.00	Matthews, 1981
Gloucester	166	2	1	0	1.61	0.00	1.20	Simmonds *et al.*, 2008: 65
Winchester	783	0	0	0	0.00	0.00	0.00	Booth *et al.*, 2010
Roman Britain	1527	7	7	0			0.46	Roberts and Cox, 2003: 158

Table 4.35: CPR of dislocation at York, comparative towns and Roman Britain

Table 4.35 shows CPR of dislocation in the York assemblage, at comparative sites and in Roman Britain. Of all observed populations, only three (York, Dorchester and Gloucester) have examples of dislocated joints. The given CPR for Roman Britain is only based on data for three archaeological assemblages, one of which is Poundbury, for which data is also included for the town of Dorchester in the present project. The Dorchester individuals therefore make up almost half of the affected individuals for Roman Britain. Additionally, further investigation indicated that all three of the dislocations from Dorchester (more specifically, Poundbury), were actually congenital hip dislocations (hip dysplasia) rather than being traumatic. All affected individuals, including those in the Roman Britain sample, are male.

CPR of traumatic joint dislocation in the York assemblage is slightly lower than the proposed average for Roman Britain. As the number of affected individuals is lower than five at every town, it was not considered appropriate to conduct a chi-square test: a Fisher's Exact test was conducted instead. The results of this test showed that crude prevalence of dislocation was not significantly different from expected rates.

4.3.1.4. Spondylolysis

Spondylolysis is a defect in the neural arch of the vertebrae, whereby the neural arch separates from the rest of the vertebral body (Aufderheide and Rodríguez-Martin, 1998: 63). Spondylolysis usually occurs in the lumbar vertebrae (Stirland, 1996: 93), more specifically L5. The aetiology of spondylolysis is varied. Roberts (2000: 342) states that the condition might be related to stresses caused by physical activity. In the modern period, there is a high frequency of spondylolysis amongst athletes (including female gymnasts, male cricket bowlers and male American footballers) and Inuit populations (Knüsel, 2000: 391). It has been suggested that spondylolysis can be caused by hyperflexion of the lumbar spine, causing repeated micro-trauma of the pars interarticularis, which may result in a stress fractures (Stewart, 1953; Fibiger and Knüsel, 2005: 165). The majority of examples are likely to be caused by trauma, though high frequency of spondylolysis in some skeletal populations, such as the Inuit - has led some researchers to suggest a genetic origin or predisposal to the condition (Knüsel, 2000: 391).

Seven individuals were observed with spondylolysis, in either the fourth or fifth lumbar vertebrae. In one individual, the exact lumbar vertebra affected was unknown; this individual can therefore only be included in crude prevalence calculations. Table 4.36 shows TPR of spondylolysis in the York assemblage. As expected, spondylolysis is most prevalent in the fifth lumbar vertebrae.

Element	Total Elements	Affected Elements	TPR%
L4	152	1	0.66
L5	152	5	3.29

Table 4.36: TPR of spondylolysis per affected vertebra

Table 4.37 shows CPR of spondylolysis in the York assemblage, comparative populations and for Roman Britain.

	Total No. Individuals	Total Affected	M	F	M CPR%	F CPR%	Total CPR%	Reference
York	785	7	5	1	1.70	0.64	0.89	This study
Ancaster	327	1					0.31	Cox, 1989: 70
Cirencester	424	0	0	0	0.00	0.00	0.00	McWhirr *et al.*, 1982
Colchester	733	1	0	1	0.00	0.56	0.14	Crummy *et al.*, 1993: 76
Derby	112	0	0	0	0.00	0.00	0.00	Wheeler, 1985
Dorchester	1511	27	11	16	2.50	3.44	1.79	Farwell and Molleson, 1993: 187; Davies *et al.*, 2002; Egging Dinwiddy, 2009
Dunstable	112	0	0	0	0.00	0.00	0.00	Matthews, 1981
Gloucester	166	4	2	1	3.23	4.00	2.41	Simmonds *et al.*, 2008: 58
London	869	3	3	0	1.20	0.00	0.35	Barber and Bowsher, 2000: 264-97; MOLA Centre for Human Bioarchaeology, 2009a; MOLA Centre for Human Bioarchaeology, 2009b
Winchester	783	5	3	2	1.40	0.92	0.64	Booth *et al.*, 2010: 370
Roman Britain	2475	49	26	20			1.98	Roberts and Cox, 2003: 151-2

Table 4.37: CPR of spondylolysis at York, comparative towns and Roman Britain

Table 4.37 shows that CPR of spondylolysis in the York assemblage is lower than average for Roman Britain, but within both the observed range (0.2-8.3%) calculated by Roberts and Cox (2003: 151-2) and the range of the comparative towns also listed above. There was no significant difference in prevalence of spondylolysis between males and females. A Fisher's Exact test showed that across all populations, observed prevalence of spondylolysis was significantly different from expected prevalence (Fisher's Exact=30.28, p=<0.01). Further testing showed that when all the Dorchester and Gloucester data were removed together, and the test performed again, the results were no longer significant (Fisher's Exact=7.10, p=0.316). This may suggest that the Dorchester and Gloucester data skewed the original test result, indicating that all other sites are within the expected range.

Osteoarchaeological research has suggested that calculated British prevalence rates for spondylolysis in Britain (across all periods) is lower than should be expected. For example, studies from outside Britain and also clinical studies have suggested that even taking into account temporal and spatial differences, spondylolysis should be present in a much larger proportion of archaeological populations than is often observed (Fibiger and Knüsel, 2005). Clinical prevalence of spondylolysis is frequently quoted as being 5-7% (D'Orazio, 1999: 98). Fibiger and Knüsel's (2005) study of spondylolysis in British skeletal populations suggested that prevalence may be anywhere up to 12%. Mays (2006a) subsequent study of spondylolysis in the medieval skeletal assemblage from Wharram Percy found a total CPR of 11.9%. Although these studies utilise skeletal samples from British populations later in date than the populations examined in this study, the figures still suggest that there may be a deficit in the quantity of spondylolysis observed in earlier British populations.

4.3.1.5. Peri-Mortem Trauma

With regards to the York assemblage, peri-mortem trauma falls into four broad categories: decapitation, blade injuries, blunt force trauma and miscellaneous possible peri-mortem trauma. Fifty-two individuals displayed evidence for decapitation (e.g. Figures 4.23-4.25), 13 individuals had blade injuries, eight individuals had blunt force trauma and a further seven individuals had peri-mortem trauma that, due to the descriptions given in the associated reports, could not be categorised any further than "miscellaneous". It should also be noted that the majority of individuals exhibiting peri-mortem trauma are associated with one particular burial location at Driffield Terrace. This will be discussed further in Chapter 5.

Figure 4.23: Posterior aspect, fifth cervical vertebra. Decapitation. SK 1, The Mount School, Driffield Terrace (McIntyre, 2011)

Figure 4.24: Anterior aspect, fifth cervical vertebra. Decapitation. SK 4, The Mount School, Driffield Terrace (McIntyre, 2011)

Figure 4.25: Posterior aspect, fifth cervical vertebra. Decapitation. SK 9, The Mount School, Driffield Terrace (McIntyre, 2011)

Peri-mortem trauma is not directly relevant to this study; while it does provide potentially valuable information about cause of death or ritual/funerary practices, this category of trauma is not relevant to the long term health status of the population. Conversely, it would also be inappropriate to completely disregard this form of trauma from such a broad pathological study. In light of this, TPR of each of the four types of peri-mortem trauma are presented in Tables 4.38-4.41. TPR of peri-mortem trauma in all elements not listed in the tables below is 0%.

Decapitation

Element	**Total Elements**	**Total Affected**	**L**	**R**	**Unsided**	**L TPR%**	**R TPR%**	**Total TPR%**
Temporal	569	1	0	1		0.00	0.35	0.18
Mandible	295	5	7	6	1	2.46	2.08	1.69
first Rib	2956	1	1	0		0.07	0.00	0.03
C1	146	3						2.05
C2	135	10						7.41
C3	127	16						12.60
C4	117	17						14.53
C5	120	20						16.67
C6	122	18						14.75
C7	126	7						5.56
T1	140	1						0.71
T2	140	2						1.43
Clavicle	478	1	0	1		0.00	0.43	0.21

Table 4.38: TPR of decapitation per affected skeletal element

Blade Injuries

Element	Total Elements	Total Affected	L	R	Unsided	L TPR%	R TPR%	Total TPR%
Parietal	603	2	1	1		0.34	0.33	0.33
Temporal	569	2	0	1	1			0.35
Mandible	295	1						0.34
Ribs	2956	2	0	1	1	0.00	0.07	0.07
C5	120	1						0.83
C7	126	1						0.79
T1	140	2						1.43
T3	141	1						0.71
T11	141	1						0.71
T12	136	1						0.74
Clavicle	478	1	0	1		0.00	0.43	0.21
Scapula	311	1	0	1		0.00	0.66	0.32
Ulna	595	1	0	1		0.00	0.34	0.17
Ilium	384	2	0	2		0.00	1.09	0.52
Sacrum	151	1						0.66
Femur	736	1	0	1		0.00	0.29	0.14

Table 4.39: TPR of peri-mortem blade injury per affected skeletal element

Blunt Force Trauma

Element	Total Elements	Total Affected	L	R	L TPR%	R TPR%	Total TPR%
Frontal	296.5	3					1.01
Parietal	603	4	3	1	1.01	0.33	0.66
Occipital	303.5	2					0.66
Maxilla	507	1	0	1	0.00	0.40	0.20
Clavicle	478	1	0	1	0.00	0.43	0.21

Table 4.40: TPR of peri-mortem blunt force trauma per affected skeletal element

Miscellaneous Peri-Mortem Trauma

Element	Total Elements	Total Affected	L	R	L TPR%	R TPR%	Total TPR%
Frontal	296.5	2					0.67
Parietal	603	4	2	2	0.67	0.67	0.66
Occipital	303.5	2					0.66
Mandible	295	1	0	1	0.00	0.35	0.34
Ulna	595	2	2	0	0.69	0.00	0.34
Metacarpals	1109	1	0	1	0.00	0.17	0.09

Table 4.41: TPR of miscellaneous peri-mortem trauma per affected skeletal element

These four tables indicate several things. In decapitated individuals, the most commonly involved elements are the fourth to sixth cervical vertebrae. Blade injuries were most likely to be located around the first thoracic vertebra. Blunt force trauma was most commonly found in the cranium, more specifically the frontal. All these findings will be discussed further in Chapter 5.

Tables 4.42-4.44 show CPR of decapitation, peri-mortem blade injury and peri-mortem blunt force trauma in the York assemblage, comparative populations and Roman Britain.

	Total No. Individuals	Total Affected	M	F	M CPR%	F CPR%	Total CPR%	Reference
York	785	52	50	0	17.01	0.00	6.62	This study
Ancaster	327	0	0	0	0.00	0.00	0.00	Cox, 1989
Cirencester	424	6	5	1	2.04	1.00	1.42	McWhirr *et al.*, 1982: 194
Colchester	733	0	0	0	0.00	0.00	0.00	Crummy *et al.*, 1993
Derby	112	4	2	1	10.53	3.45	3.57	Wheeler, 1985: 244-8
Dorchester	1511	7	3	4	0.68	0.86	0.46	Farwell and Molleson, 1993: 203-5; Davies *et al.*, 2002: 152; Egging Dinwiddy, 2009: 32-4
Dunstable	112	12	5	6	10.87	14.29	10.71	Matthews, 1981: 38
Gloucester	166	1	0	1	0.00	4.00	0.60	Simmonds *et al.*, 2008: 56
East London	550	6	2	2	1.08	1.83	1.09	Barber and Bowsher, 2000: 89
Winchester	783	5	1	1	0.47	0.46	0.64	Booth *et al.*, 2010: 368-70
Roman Britain	1052	58	23	12			5.51	Roberts and Cox, 2003: 158

Table 4.42: CPR of decapitation at York, comparative towns and Roman Britain

	Total No. Individuals	Total Affected	M	F	M CPR%	F CPR%	Total CPR%	Reference
York	785	13	10	1	3.40	0.64	1.66	This study
Ancaster	327	1	0	1	0.00	1.20	0.31	Cox, 1989: 46-7
Cirencester	424	2	2	0	0.82	0.00	0.47	McWhirr *et al.*, 1982: 168-71
Colchester	733	0	0	0	0.00	0.00	0.00	Crummy *et al.*, 1993
Derby	112	0	0	0	0.00	0.00	0.00	Wheeler, 1985
Dorchester	1511	1	0	1	0.00	0.22	0.07	Farwell and Molleson, 1993: 203-5; Davies *et al.*, 2002; Egging Dinwiddy, 2009
Gloucester	166	1	1	0	1.61	0.00	0.60	Simmonds *et al.*, 2008: 56-7
Winchester	783	0	0	0	0.00	0.00	0.00	Booth *et al.*, 2010
Roman Britain	454	6	6	0			1.32	Roberts and Cox, 2003: 158

Table 4.43: CPR of peri-mortem blade injury at York, comparative towns and Roman

	Total No. Individuals	Total Affected	M	F	M CPR%	F CPR%	Total CPR%	Reference
York	785	8	4	2	1.36	1.28	1.02	This study
Cirencester	424	0	0	0	0.00	0.00	0.00	McWhirr *et al.*, 1982
Colchester	733	0	0	0	0.00	0.00	0.00	Crummy *et al.*, 1993
Dorchester	1511	1	0	1	0.00	0.22	0.07	Farwell and Molleson, 1993; Davies *et al.*, 2002; Egging Dinwiddy, 2009: 33
Gloucester	166	0	0	0	0.00	0.00	0.00	Simmonds *et al.*, 2008

Table 4.44: CPR of peri-mortem blunt force trauma at York, comparative towns and Roman Britain

Prevalence of peri-mortem trauma clearly appears to be elevated in York when compared to other urban populations, and there is a clear male bias. This will be discussed in Chapter 5.

4.3.1.6. Summary: Trauma

To summarise, Figure 4.26 shows the prevalence distribution of all types of observed trauma across all populations.

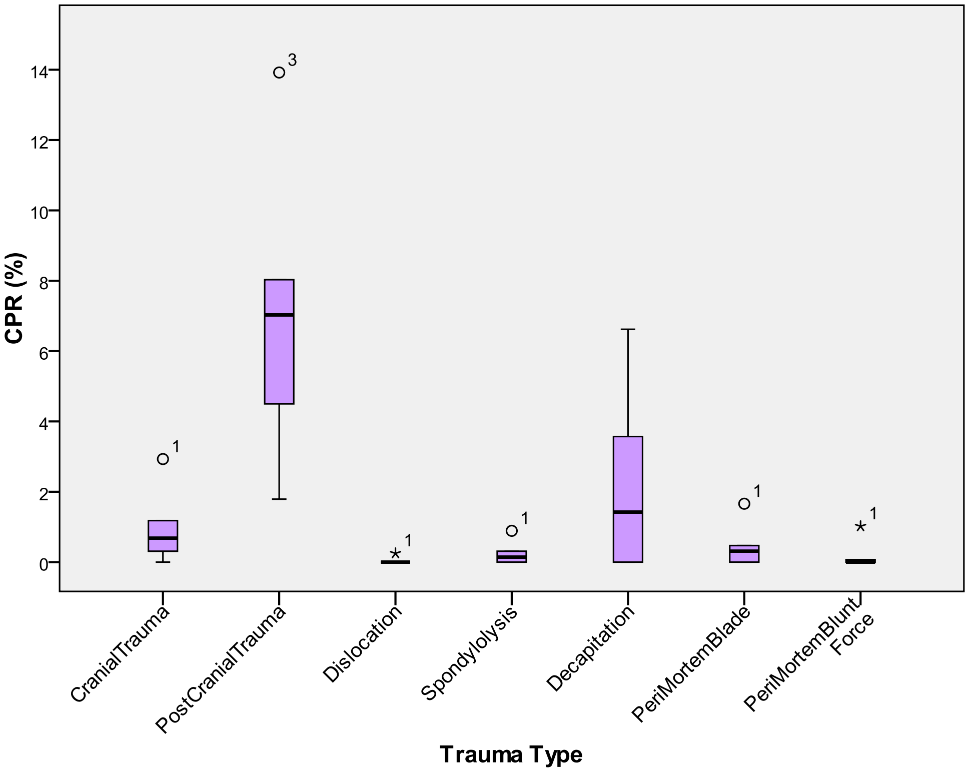

Figure 4.26: Crude distribution of trauma across all towns. 1 represents the town of York, and 3 represents the town of Colchester. O represents an outlaying value. * represents an extreme outlaying value

Large prevalence ranges for post-cranial trauma and decapitation between populations, suggesting that prevalence of this type of trauma could vary considerably. Cranial trauma, dislocation, spondylolysis, peri-mortem blade injury and peri-mortem blunt force trauma have narrow prevalence ranges between sites (0-2%), suggesting that prevalence of this type of trauma should generally be at a consistently low level across urban settlements in Roman Britain.

In view of this, York has high, outlying values for cranial trauma, dislocation, and peri-mortem blade injury, and is an extreme outlier for spondylolysis and peri-mortem blunt force trauma. Some of these elevated values are heavily correlated with individuals from the Driffield Terrace area of York. Cirencester is an outlier for post-cranial trauma. These results will be discussed further in Chapter 5.

4.3.2. Congenital Conditions and Developmental Abnormalities

This section includes evidence of spina bifida, sacralisation, and os acromiale. No evidence of other congenital malformations such as scoliosis, cervical ribs, costal fusion, bifid ribs, Calcaneus Secundarius, Klippel-Feil syndrome, hydrocephalus, cleft palate and lumbarisation were observed.

4.3.2.1. Spina Bifida

Individuals with spina bifida experience congenital incomplete fusion of the sacral posterior neural arches. Spina bifida is commonly observed in archaeological populations from all periods in Britain (Aufderheide and Rodríguez-Martin, 1998: 61-2). It has been postulated that adult archaeological individuals exhibiting skeletal symptoms are more likely to have spina bifida occulta, as more serious forms such as spina bifida cystica are incompatible with long life: Morse, 1978; Aufderheide and Rodríguez-Martin, 1998: 62; Roberts and Cox, 2003: 31). A total of 14 individuals were observed with sacral defects characteristic of spina bifida, giving a TPR of 9.27%. Table 4.45 shows CPR of spina bifida in the York assemblage, comparative sites and Roman Britain.

Prevalence of spina bifida in the York assemblage is slightly higher than prevalence rates from other populations, but is very similar to the average rate calculated for Roman Britain. A Fisher's Exact test was performed to examine spina bifida prevalence across all observed sites. The result was significant (Fisher's Exact=19.86, p=<0.01), indicating that prevalence of spina bifida in the observed populations is significantly different from expected values. Further Fisher's Exact testing revealed that there was no significant difference between sites when data from Winchester was removed from the test (Fisher's Exact=9.19, p=0.13). This indicates that the Winchester data was skewing the original test result. Therefore, prevalence of spina bifida at Winchester is significantly higher than expected. All other populations, including York, were therefore within the expected range.

	Total No. Individuals	Total Affected	M	F	M CPR%	F CPR%	Total CPR%	Reference
York	785	14	13	1	4.42	0.64	1.78	This study
Ancaster	327	0	0	0	0.00	0.00	0.00	Cox, 1989
Cirencester	424	5	4	1	1.63	1.00	1.18	McWhirr *et al.*, 1982: 144
Colchester	733	7	5	2	2.76	1.13	0.95	Crummy *et al.*, 1993: 8; 16-19; 33 and 66-7
Derby	112	0	0	0	0.00	0.00	0.00	Wheeler, 1985
Dorchester	1511	23	8	5	1.82	1.08	1.52	Farwell and Molleson, 1993: 187; Davies *et al.*, 2002: 153; Egging Dinwiddy, 2009: 24
Gloucester	166	1	0	1	0.00	4.00	0.60	Simmonds *et al.*, 2008: 57
Winchester	783	1	1	0	0.47	0.00	0.13	Booth *et al.*, 2010: 372
Roman Britain	3441	58	33	14			1.69	Roberts and Cox, 2003: 117

Table 4.45: CPR of spina bifida at York, comparative towns and Roman Britain

Another chi-square test was performed to examine prevalence of spina bifida according to sex in the York assemblage. The chi-square value (χ=4.83) was significant at the 95% confidence interval (p=0.04), indicating that York males were significantly more prone to spina bifida than females. This is consistent with modern clinical findings (Fidas *et al.*, 1987; Eubanks and Cheruvu, 2009).

4.3.2.2. Sacralisation

Nine individuals from York had sacralised vertebrae. Table 4.46 shows the number and location of affected vertebrae, as well as TPR for each element.

Element	Total Elements	Total Affected	TPR%
L5	152	3	1.97
L6	6	6	100.00

Table 4.46: TPR of sacralisation per affected

Table 4.46 shows that sacralisation in the York assemblage involves either the fifth or sixth lumbar vertebrae. Interestingly, 100% of observed L6 vertebrae are sacralised. The presence of a sixth lumbar vertebra usually suggests that the first sacral vertebra is not fused (or only partially fused) to the rest of the sacrum; this is known as lumbarisation (Bron *et al.*, 2007: 687; Kanchan *et al.*, 2009: 86). However, in these six cases it appears that there are the usual five lumbar vertebrae present, plus a sixth sacralised L6, plus the usual S1. Other than these examples, no further cases of lumbarisation were recorded. While cases of a sacralised sixth lumbar vertebra have been documented in the osteological literature (Harman and Wilson, 1981; Lundy, 1988), this author has found little research regarding patterns or prevalence of this developmental condition; clinical literature has a clear focus on the effect of sacralisation or lumbarisation on back pain or association with other conditions.

Table 4.47 shows that York and all other comparative populations in this study had lower prevalence of sacralisation than expected for the period. Clinical incidence of sacralisation in modern studies has been shown to range from 4-24% depending on the sample size and population from which the sample was taken (Delport *et al.*, 2006).

A Fisher's Exact test was performed to examine sacralisation prevalence across all observed populations. The results were significant (Fisher's Exact=25.18, p=<0.01), indicating that prevalence of sacralisation at the above sites is significantly different from expected values. When a second Fisher's Exact test was performed excluding the York data, the difference was still significant (Fisher’s Exact=20.40, p=<0.01). Further Fisher’s Exact testing showed that results were still significant when data from Dorchester were excluded (Fisher’s Exact=13.69, p=0.048), but to a much lesser extent. This suggests that the results of the original Fisher’s Exact test were skewed by inclusion of the Dorchester data (which suggests that prevalence of sacralisation at Dorchester is slightly lower than expected). However, there is still a lot of variation in the prevalence of sacralisation across all observed populations, and the significant difference indicated by the first test results is not wholly related to observed prevalence at one population alone.

	Total No. Individuals	**Total Affected**	**M**	**F**	**M CPR%**	**F CPR%**	**Total CPR%**	**Reference**
York	785	9	6	2	2.04	1.28	1.15	This study
Cirencester	424	1	0	1	0.00	1.00	0.24	McWhirr *et al.*, 1982: 201
Colchester	733	1	0	1	0.00	0.56	0.14	Crummy *et al.*, 1993: 65
Derby	112	0	0	0	0.00	0.00	0.00	Wheeler, 1985
Dorchester	1511	1	1	0	0.23	0.00	0.07	Farwell and Molleson, 1993; Davies *et al.*, 2002: 153; Egging Dinwiddy, 2009
Dunstable	112	2	1	1	2.17	2.38	1.79	Matthews, 1981: 40
Gloucester	166	0	0	0	0.00	0.00	0.00	Simmonds *et al.*, 2008
Winchester	783	3	1	2	0.47	0.92	0.38	Booth *et al.*, 2010: 371
Roman Britain	2939	72	39	16			2.45	Roberts and Cox, 2003; 116-7

Table 4.47: CPR of sacralisation at York, comparative towns and Roman Britain

A chi-square test was performed to examine prevalence of sacralisation according to sex in the York assemblage. No significant difference was found between males and females. This is consistent with palaeopathological findings (Aufderheide and Rodríguez-Martin, 1998: 66).

4.3.2.3. Os Acromiale

Os acromiale is an accessory bone resulting from non-union of the acromial epiphysis in the scapula (Case *et al.,* 2006: 2). The development of the condition has been discussed comprehensively in the literature, particularly by Miles (1994) and Sammarco (2000). Several factors are thought to influence the occurrence of os acromiale, including body size (Case *et al.,* 2006; 5), acromioclavicular joint placement, trauma, genetic predisposition, and mechanical stress (Hope, 2008: 11-17).

Os acromiale was observed in 14 individuals; of these 14 only three had bilateral involvement. Table 4.48 shows TPR of os acromiale in the York assemblage.

Element	**Total Elements**	**Total Affected Elements**	**L**	**R**	**L TPR%**	**R TPR%**	**Total TPR%**
Scapula	311	17	11	6	7.59	3.95	5.47

Table 4.48: TPR of os acromiale

Occurrence of os acromiale was more frequent in the left scapula. A chi-square test was performed to examine prevalence of os acromiale in the left and right scapulae. The chi-square value (χ=76.246) was significant at the 95% confidence interval (p=<0.001), indicating that prevalence of os acromiale was significantly higher in the left scapula. If this finding is reflective of occupational activity, it indicates that repeated mechanical stress was more likely to be placed on the left shoulder then the right.

Table 4.49 shows that York is the only site in this study where os acromiale has been observed. It is unknown whether this is due to genuine absence or differential recording strategy (at least in some of the older reports) which resulted in the condition not being recorded. Calculated prevalence for Roman Britain utilises a much smaller sample than that of York; this prevalence rate was only calculated using date from four sites. Incorporating the data from York produces a new TPR for Roman Britain of 2.2%.

	Total No. Individuals	**Total Affected**	**M**	**F**	**M CPR%**	**F CPR%**	**Total CPR%**	**Reference**
York	785	14	12	1	4.08	0.64	1.78	This study
Ancaster	327	0					0.00	Cox, 1989
Cirencester	424	0					0.00	McWhirr *et al.*, 1982
Colchester	733	0					0.00	Crummy *et al.*, 1993
Derby	112	0					0.00	Wheeler, 1985
Dorchester	1511	0					0.00	Chambers, 1987; Farwell and Molleson, 1993; Davies *et al.*, 2002; Egging Dinwiddy, 2009
Dunstable	112	0					0.00	Matthews, 1981
Gloucester	166	0					0.00	Simmonds *et al.*, 2008
London	183	0					0.00	MOLA Centre for Human Bioarchaeology, 2009a; MOLA Centre for Human Bioarchaeology, 2009b
Winchester	783	0					0.00	Booth *et al.*, 2010
Roman Britain	308	10	3	6			3.25	Roberts and Cox, 2003: 158

Table 4.49: CPR of os acromiale at York, comparative towns and Roman Britain

Os acromiale was also present more frequently in males than females in the York assemblage. A chi-square test was conducted in order to examine prevalence according to sex. The chi-square value (χ=4.30) was significant at the 95% confidence interval (p=0.04), indicating that prevalence of os acromiale was significantly higher in males. Both sex and side bias strongly supports a mechanical aetiology over genetic predisposition for the condition within the York population (Case *et al.*, 2006: 13).

4.3.2.4. Summary: Congenital Conditions and Developmental Abnormalities

To summarise, Figure 4.27 shows the prevalence distribution of all types of observed congenital and developmental conditions across all populations.

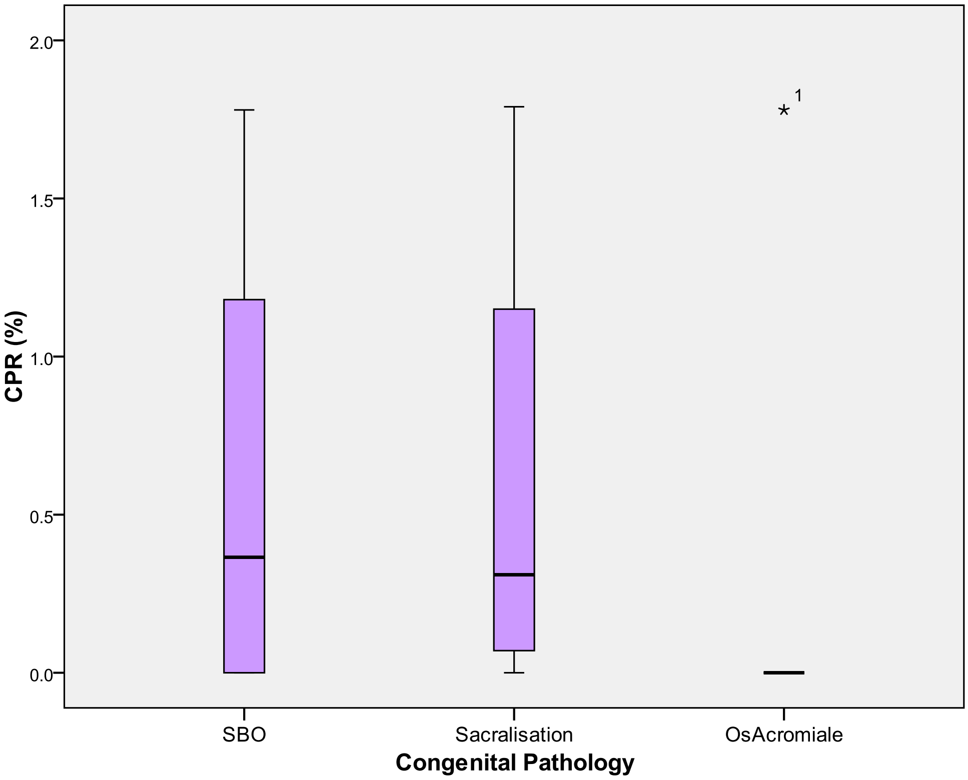

Figure 4.27: Crude distribution of congenital pathology across all towns. 1* represents York as an extreme outlaying value

Overall ranges for spina bifida and sacralisation are relatively narrow, indicating that urban populations in Roman Britain are generally likely to have consistently low levels of these two pathological conditions. The York population fits comfortably within these distributions. However, York is an extreme outlier in the os acromiale distribution, chiefly because no other examples of this condition were recorded at other comparative sites. This could either be the result of differential recording strategy, where observers missed or did not record os acromiale, or be because individuals (primarily males) in the York population were partaking in tasks that would inhibit acromial fusion.

4.3.3. Circulatory Disorders

This section includes evidence of osteochondritis dissecans. No evidence of other circulatory disorders such as osteochondrosis was observed.

4.3.3.1. Osteochondritis Dissecans

Osteochondritis dissecans is a noninflammatory, benign condition where small areas of necrosis are produced in epiphyseal areas of the diarthrodial joints, resulting in complete or partial detachment of a fragment of subchondral bone (Aufderheide and Rodríguez-Martin, 1998: 81). The condition is thought to be the result of repeated microtrauma at specific locations, and in modern populations is seen frequently in athletes (Aufderheide and Rodríguez-Martin, 1998: 81, Schenk and Goodnight, 2006: 449).

Osteochondritis dissecans was observed in eight individuals, and only in bones of the legs and feet. Table 4.50 shows the TPR of osteochondritis dissecans according to skeletal element. All skeletal elements not included in the table have a TPR of 0%.

Element	Total Individuals Affected	Total Elements	Total Affected Elements	L	R	L TPR%	R TPR%	Total TPR%
Femur	2	736	2	1	1	0.28	0.29	0.27
Tibia	2	592	2	0	2	0.00	0.72	0.34
Tarsals	2	1186	3	1	2	0.17	0.33	0.25
Metatarsals	2	978	3	1	2	0.21	0.41	0.31

Table 4.50: TPR of osteochondritis dissecans per affected skeletal element

Osteochondritis dissecans is most prevalent in the tibia (e.g. Figure 4.28), although prevalence does not differ much between all the affected elements. Prevalence in the tarsals and metatarsals may have been higher had this study made individual counts for each specific bone. The knee and ankle are joints commonly affected by osteochondritis dissecans, with the femur being one of the bones most commonly involved (Aufderheide and Rodríguez-Martin, 1998: 82; Rogers, 2000: 179). The right side was more frequently affected than the left side, although this difference was not statistically significant.

Figure 4.28: Osteochondritis dissecans, superior aspect of the medial condyle, right tibia. From section T2A-5, Trentholme Drive (McIntyre, 2011)

Table 4.51 shows CPR of osteochondritis dissecans in the York assemblage, comparative populations and Roman Britain. This table shows that prevalence of osteochondritis dissecans is quite variable between populations. York is at the lower end of the prevalence scale, but still has slightly higher prevalence than expected for Roman Britain. There is male bias in frequency of osteochondritis dissecans across sites listed in Table 4.51 (in the York assemblage this difference is not statistically significant). Osteochondritis dissecans is generally thought to occur more commonly in males (Aufderheide and Rodríguez-Martin, 1998: 82; Rogers, 2000: 179; Schenk and Goodnight, 2006: 439).

	Total No. Individuals	Total Affected	M	F	M CPR%	F CPR%	Total CPR%	Reference
York	785	8	7	0	2.38	0.00	1.02	This study
Ancaster	327	2	2	0	1.55	0.00	0.61	Cox, 1989: 40
Cirencester	424	39	25	11	10.20	11.00	9.20	McWhirr *et al.*, 1982: 201
Colchester	733	26	16	10	8.84	5.65	3.55	Crummy *et al.*, 1993: 91
Derby	112	0	0	0	0.00	0.00	0.00	Wheeler, 1985
Dorchester	1511	7	2	0	0.45	0.00	0.46	Farwell and Molleson, 1993: 188; Davies *et al.*, 2002: 153; Egging Dinwiddy, 2009: 25
Gloucester	166	1	0	1	0.00	4.00	0.60	Simmonds *et al.*, 2008: 60
St. Albans	27	1	1	0	10.00	0.00	3.70	McKinley, 1992
Winchester	783	1	1	0	0.47	0.00	0.13	Booth *et al.*, 2010: 375
Roman Britain	2721	11	7	3			0.40	Roberts and Cox, 2003: 152

Table 4.51: CPR of osteochondritis dissecans at York, comparative towns and Roman

A Fisher’s Exact test was performed to examine prevalence of osteochondritis dissecans across all observed sites. The test results were significant (Fisher’s Exact=127.14, p=<0.01), indicating that prevalence of osteochondritis dissecans at the above sites is significantly different from expected values. Further testing indicated that this significant result was likely to be influenced by the variation in prevalence and frequency of the condition across all populations: there was no single prevalence rate responsible for skewing the dataset.

4.3.3.2. Summary: Circulatory Disorders

To summarise, Figure 4.29 shows the prevalence distribution of all types of observed circulatory disorders across all sites.

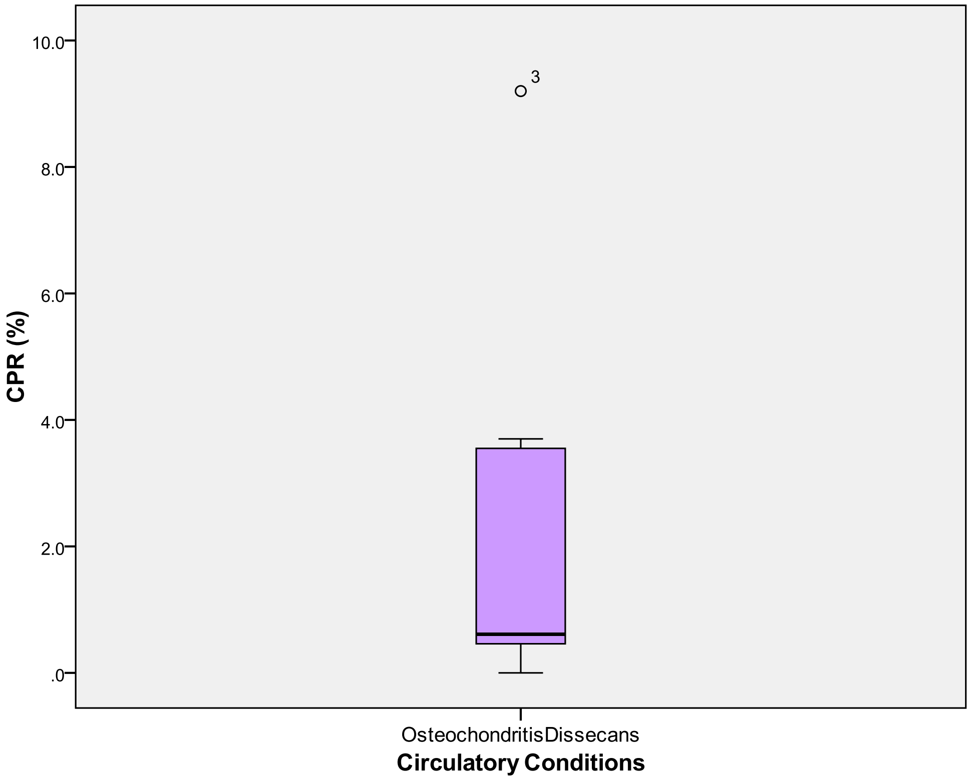

Figure 4.29: Crude distribution of circulatory conditions across all towns. 3O represents Cirencester as an outlaying value

Prevalence distribution for osteochondritis dissecans is moderately narrow. The low median value shows that the overall distribution is likely to have been affected by a the slightly larger prevalence rates observed Colchester and St. Albans; most urban sites in Roman Britain are therefore likely to have a prevalence rate of around 1%. The outlying value in Figure 4.29 is for Cirencester, suggesting that either the population were partaking in activities that would be more likely to cause this condition, or that the condition was somewhat over diagnosed in the sample.

4.3.4. Joint Disease

This category of pathological condition includes evidence of spinal and extra-spinal joint disease, Schmorl's nodes, gout, and one case of sacroiliac fusion. This one case may be indicative of ankylosing spondylitis or Diffuse Idiopathic Skeletal Hyperostosis (DISH), but there is insufficient evidence to confirm the exact cause. No other joint diseases such as specific forms of arthritis (rheumatoid etc) were observed.

4.3.4.1. Spinal Joint Disease

A total of 98 individuals were observed with spinal joint disease. Not all individuals had spinal joint disease recorded per vertebrae; these individuals are included in CPR calculations but could not be included in TPR calculations. Table 4.52 shows CPR of spinal joint disease per vertebral category. Table 4.53 shows TPR of spinal joint disease per vertebrae.

Tables 4.52-4.53 show that the distribution of spinal joint disease is generally bimodal, peaking in the mid thoracic and lumbar vertebrae, more specifically around the seventh and eighth thoracic and fourth and fifth lumbar vertebrae. The anomalously high prevalence observed in L6 should be discounted, as the sample size is much smaller.

Vertebral Category	No. Affected Individuals	CPR% (Of Whole Population)	CPR% (Of Total Affected by Spinal DJD)
Cervical	29	3.69	31.18
Thoracic	54	6.88	58.06
Lumbar	47	5.99	50.54
Sacral (S1)	9	1.15	9.68

Table 4.52: CPR of spinal joint disease per vertebral category

Element	Total Present	Total Affected	TPR%
C1	146	11	7.53
C2	135	14	10.37
C3	127	12	9.45
C4	117	10	8.55
C5	120	12	10.00
C6	122	12	9.84
C7	126	10	7.94
T1	140	13	9.29
T2	140	5	3.57
T3	141	11	7.80
T4	142	19	13.38
T5	145	19	13.10
T6	146	19	13.01
T7	139	26	18.71
T8	141	26	18.44
T9	144	23	15.97
T10	140	20	14.29
T11	141	20	14.18
T12	136	19	13.97
T13	2	0	0.00
L1	146	19	13.01
L2	148	22	14.86
L3	147	23	15.65
L4	152	24	15.79
L5	152	24	15.79
L6	6	2	33.33
S1	151	9	5.96

Table 4.53: TPR of spinal joint disease per affected vertebra

Table 4.54 shows CPR of spinal joint disease in the York assemblage, comparative populations and Roman Britain. CPR of spinal joint disease in York is also shown including data from Peck (2009). The results show that observed rates of spinal joint disease in material from this study produces a CPR that approximates the expected CPR for Roman Britain. However, with the addition of the data from the Peck (2009) study, CPR of spinal joint disease in the same population is elevated by more than 5%. Across all populations, York has the third highest prevalence of spinal joint disease, after Cirencester and St. Albans. The high rate observed at St. Albans may be at least partially related to the small sample size. A Fisher's Exact test performed to examine prevalence of spinal joint disease across all observed sites. The York sample included Trentholme Drive data from Peck (2009).

	Total No. Individuals	Total Affected	M	F	M CPR%	F CPR%	Total CPR%	Reference
York	785	98	58	23	19.73	14.74	12.48	This study
York (inc. Trentholme Drive)	1044	186	125	57	31.41	26.51	17.82	This study; Peck, 2009
Ancaster	327	7	3	0	2.33	0.00	2.14	Cox, 1989: 56-60
Cirencester	424	190	127	63	51.84	63.00	44.81	McWhirr *et al.*, 1982: 152-7
Colchester	733	79	50	28	27.62	15.82	10.78	Crummy *et al.*, 1993: 8, 16-19, 33 and 85
Dorchester	1417	155	85	70	21.36	15.70	10.94	Farwell and Molleson, 1993: 201-2; Egging Dinwiddy, 2009: 27-9
Dunstable	112	3					2.68	Matthews, 1981: 40
St. Albans	27	9					33.33	McKinley, 1992
Winchester	783	51					6.51	Booth *et al.*, 2010: 375-9
Roman Britain	3111	405	186	125			13.02	Roberts and Cox, 2003: 145-6

Table 4.54: CPR of spinal joint disease at York, comparative towns and Roman Britain

Results were significant (Fisher's Exact=387.74, p=<0.01), indicating that prevalence of spinal joint disease was also significantly different from expected values across all observed sites. Further Fisher's Exact testing showed that this significant difference could not be attributed to one site alone. Therefore, the results suggest that the prevalence range for spinal joint disease during the Roman period was highly variable. This suggestion is discussed further at the end of this chapter (see page 253).

A chi-square test was conducted to compare prevalence of spinal joint disease in males and females. No significant difference was found between the sexes, either when data from this study was tested or when Peck's (2009) data were included in the calculation.

All the above findings suggest that, in accordance with the results of the Peck (2009) study, the population of Roman York had elevated levels of spinal joint disease in the lower spine, particularly in the mid thoracic and lower lumbar regions. These findings indicate that, as with the Trentholme Drive assemblage (Peck, 2009: 175-6), both male and female individuals in the remainder of the York population were placing increased amounts of biomechanical stress on these regions of the spine, possibly as a result of, or exacerbated by, heavy lifting.

4.3.4.2. Schmorl's Nodes

A total of 99 individuals from the York assemblage had Schmorl's nodes. Table 4.55 shows CPR of Schmorl's nodes according to spinal Table 4.56 shows TPR of Schmorl's nodes per vertebrae. No Schmorl's nodes were observed in any of the cervical vertebrae, giving each of these a TPR of 0%.

Vertebral Category	No. Affected Individuals	CPR% (Of Whole Population)	CPR% (Of Total Affected by Spinal DJD)
Cervical	0	0.00	0.00
Thoracic	87	11.08	87.88
Lumbar	55	7.01	55.56
Sacral	2	0.25	2.02

Table 4.55: CPR of Schmorl's nodes according to vertebral region

Element	Total Present	Total Affected	TPR%
T1	140	0	0.00
T2	140	1	0.71
T3	141	3	2.13
T4	142	6	4.23
T5	145	16	11.03
T6	146	30	20.55
T7	139	41	29.50
T8	141	46	32.62
T9	144	45	31.25
T10	140	52	37.14
T11	141	47	33.33
T12	136	34	25.00
T13	2	0	0.00
L1	146	36	24.66
L2	148	33	22.30
L3	147	26	17.69
L4	152	19	12.50
L5	152	7	4.61
L6	6	2	33.33
S1	151	2	1.32

Table 4.56: TPR of Schmorl's nodes per affected vertebra

The above tables show that the prevalence of Schmorl's nodes peaks in the mid-lower thoracic section of the vertebral column, more specifically around the eighth to eleventh thoracic vertebrae with highest prevalence in T10. Again, the anomalously high prevalence observed in L6 should be discounted, as the sample size is very small.

Table 4.57 shows CPR of Schmorl's nodes in the York assemblage, comparative populations and Roman Britain. The results show that prevalence of Schmorl's nodes in the York assemblage is slightly higher than calculated prevalence for Roman Britain, and is positioned approximately mid way in the prevalence range for other observed populations in this study. A Fisher's Exact test was performed to examine prevalence of Schmorl's nodes across all observed populations. The results were significant (Fisher's Exact=388.20, p=<0.01), indicating that prevalence of Schmorl's nodes is significantly different from expected values. Further testing showed that this significant difference could not be attributed to one population alone. As with the results for spinal joint disease, the results of the statistical testing (coupled with the raw data presented in Table 4.57) suggests that the prevalence range during the Roman period was highly variable across all populations.

	Total No. Individuals	Total Affected	M	F	M CPR%	F CPR%	Total CPR%	Reference
York	785	99	76	11	25.85	7.05	12.61	This study
Cirencester	424	83	59	24	24.08	24.00	19.58	McWhirr *et al.*, 1982: 152-7
Colchester	733	11	9	2	4.97	1.13	1.50	Crummy *et al.*, 1993: 8, 16-19, 3 and 75
Dorchester	1417	18	13	5	3.27	1.12	1.27	Farwell and Molleson, 1993; Egging Dinwiddy, 2009: 27
Gloucester	166	9	6	2	9.68	8.00	5.42	Simmonds *et al.*, 2008: 58, 65
London	869	152	94	46	37.75	25.56	17.49	Barber and Bowsher, 2000: 285; MOLA Centre for Human Bioarchaeology, 2009a; MOLA Centre for Human Bioarchaeology, 2009b
St. Albans	27	6					22.22	McKinley, 1992
Winchester	783	37	23	12	10.75	5.50	4.73	Booth *et al.*, 2010: 377
Roman Britain	3040	272	124	55			8.95	Roberts and Cox, 2003: 147

Table 4.57: CPR of Schmorl's nodes at York, comparative towns and Roman Britain

A chi-square test was conducted to examine prevalence of Schmorl's nodes according to sex. The chi-square value (χ=23.10) was significant at the 95% confidence interval (p=<0.01), indicating that males had significantly higher prevalence of Schmorl's nodes than females. This is consistent with previous research regarding sex distribution of Schmorl's nodes (Faccia and Williams, 2008: 36; Dar *et al.*, 2009).

4.3.4.3. Extra-Spinal Joint Disease

A total of 103 individuals had extra-spinal joint disease. Not all individuals had joint disease recorded per element; these individuals are included in CPR calculations but could not be included in TPR calculations. Due to time constraints joint disease was not scored for severity. Table 4.58 shows TPR of extra-spinal joint disease per skeletal element. Table 4.59 shows TPR of extra-spinal joint disease per joint, based on the maximum number of joints present (see Chapter 3, page 110). All skeletal elements and joints not included Tables 4.58 and 4.59 have a TPR of 0%.

Element	Total Ind. Affected	CPR%	Total Elements Affected	L	R	U	L TPR%	R TPR%	Total TPR%
Temporal	10	1.27	14	8	6		2.82	2.10	2.46
Mandible	8	1.02	9	5	4		1.76	1.38	
Manubrium	2	0.25	2						2.44
Sternum	1	0.13	1						0.97
Clavicle	19	2.42	30	15	15		6.12	6.47	6.28
Ribs	23	2.93	87	37	44	6	2.50	3.12	2.94
Scapula	21	2.68	29	11	18		7.59	11.84	9.32
Humerus	12	1.53	16	4	12		1.28	3.70	2.44
Ulna	17	2.17	21	6	15		2.08	5.07	3.53
Radius	10	1.27	13	3	9	1	0.98	3.18	2.17
Carpals	6	0.76	10	5	5		1.26	1.15	1.20
Metacarpals	13	1.66	17	7	8	2	1.33	1.38	1.53
Proximal Hand Phalanges	7	0.89	7	2	3	2	0.50	0.70	0.80
Intermediate Hand Phalanges	2	0.25	2	2	0		0.87	0.00	0.40
Distal Hand Phalanges	2	0.25	3	2	1		1.41	0.69	1.55
Pelvis	31	3.95	44	24	20		12.83	10.93	11.46
Sacrum	3	0.38	3						1.99
Femur	26	3.31	41	21	20		5.87	5.75	5.57
Patella	7	0.89	9	4	5		4.60	6.02	5.29
Tibia	4	0.51	4	3	1		1.01	0.36	0.68
Fibula	3	0.38	4	2	2		0.88	0.84	0.81
Tarsals	7	0.89	14	7	7		1.20	1.16	1.18
Metatarsals	5	0.64	9	5	4		1.04	0.82	0.92
Proximal Foot Phalanges	7	0.89	12	5	5	2	2.05	1.99	2.26
Foot Sesamoids	1	0.13	2						6.45

Table 4.58: TPR of extra-spinal joint disease per affected skeletal element

Joint	Max. No. Joints	Total Affected	L	R	U	L TPR%	R TPR%	Total TPR%
Temperomandibular	569	11	6	5		2.12	1.75	1.93
Sternoclavicular	478	12	6	6		2.45	2.59	2.51
Acromioclavicular	478	23	11	12		4.49	5.17	4.81
Costovertebral	2957	87	37	44	6	2.50	3.12	2.94
Glenohumeral	656	19	6	13		1.92	4.01	2.90
Humeroulnar	656	16	3	13		0.96	4.01	2.44
Humeroradial	656	7	2	5		0.64	1.54	1.07
Proximal Radioulnar	599	6	1	5		0.33	1.77	1.00
Distal Radioulnar	599	8	3	5		0.98	1.77	1.34
Radiocarpal	599	9	3	5	1	0.98	1.77	1.50
Midcarpal	830	3	1	2		0.25	0.00	0.36
Carpometacarpal	1109	9	4	4	1	0.76	0.69	0.81
Metacarpophalangeal	1109	8	4	4		0.76	0.69	0.72
Interphalangeal (Hand)	1665	10	6	4		0.78	0.48	0.60
Acetabulofemoral	736	59	30	29		8.38	8.33	8.02
Sacroiliac	384	2	1	1		0.53	0.54	0.52
Tibiofemoral	736	7	4	3		1.12	0.86	0.95
Patellofemoral	736	16	8	8		2.23	2.30	2.17
Tibiofemoral	736	1	1	0		0.28	0.00	0.14
Proximal Tibiofibular	592	2	1	1		0.34	0.36	0.34
Distal Tibiofibular	592	4	2	2		0.67	0.72	0.68
Talocrural	592	3	2	1		0.67	0.36	0.51
Midtarsal	1186	18	10	8		1.72	1.32	1.52
Metatarsophalangeal	978	13	6	5	2	1.24	1.03	1.33
Interphalangeal (Foot)	717	3	1	0	2	0.30	0.00	0.42

Table 4.59: TPR of extra-spinal joint disease per affected joint (joint definitions based on Gosling *et al*., 1999)

Tables 4.58 and 4.59 show that extra-spinal joint disease is most frequent in the costovertebral and hip joints (with the ribs and femur being the most frequently involved elements). The high observed frequency in the ribs is likely to be a product of the proportionally higher number of ribs present in the assemblage. Highest prevalence of extra-spinal joint disease was observed in the hip (e.g. Figure 4.30) and acromioclavicular joints (with the pelvis and scapula having the highest prevalence of involvement). It is well documented that joint degeneration is commonly found in the hip in past populations; the hip is commonly affected because it is a major weight bearing joint (Roberts and Manchester, 1995: 113; Waldron, 1995; Waldron, 1997; Ortner, 2003: 548). Involvement of the hip seems to be especially common in pre-medieval populations, more so than in medieval and post-medieval populations (Waldron, 1995). Joint disease is also commonly found in the acromioclavicular joint in elderly patients in the modern period, and is thought to be largely age progressive (Petersson, 1983; Roberts and Manchester, 1995: 114; Burgener, 2006: 132).

Figure 4.30: Anterior view, joint disease in the right hip. This joint has become almost completely immobile. SK 10, Bar Convent (McIntyre, 2011)

Table 4.60 shows CPR of extra-spinal joint disease in the York assemblage, comparative populations and Roman Britain.

	Total No. Individuals	Total Affected	M	F	M CPR%	F CPR%	Total CPR%	Reference
York	785	103	62	26	21.09	16.67	13.12	This study
Ancaster	327	24	18	6	13.95	7.23	7.34	Cox, 1989: 50-6
Colchester	733	121	73	41	40.33	23.16	16.51	Crummy *et al.*, 1993: 8, 16-19, 33 and 85
Derby	112	6	3	3	15.79	10.34	5.36	Wheeler, 1985: 277
Dorchester	1388	186	109	77	28.61	17.66	13.40	Farwell and Molleson, 1993: 201-3
East London	686	76	47	25	23.15	16.89	11.08	Barber and Bowsher, 2000: 275; 282
St. Albans	27	1					3.70	McKinley, 1992
Winchester	783	24	15	6	7.01	2.75	3.07	Booth *et al.*, 2010: 375-9
Roman Britain	4333	479	300	159			11.05	Roberts and Cox, 2003: 146-7

Table 4.60: CPR of extra-spinal joint disease at York, comparative towns and Roman Britain

York has slightly more extra-spinal joint disease than has been predicted for Roman Britain, and sits at the higher end of the prevalence range when observing all comparative populations. A Fisher’s Exact test was performed to examine prevalence of extra-spinal joint disease across all observed populations. The result was significant (Fisher’s Exact=117.07, p=<0.01), indicating that prevalence of extra-spinal joint disease is significantly different from expected values. Further Fisher’s Exact testing showed that data from no one population was responsible for skewing the initial test result. These results, coupled with the wide variation in prevalence ranges shown in Table 4.60 suggests that like spinal joint disease and

Schmorl's nodes, prevalence of extra-spinal joint disease is highly variable between populations in the Roman period.

No significant difference was found between males and females in the York assemblage, which is consistent with previously published findings (Aufderheide and Rodríguez-Martin, 1998: 93).

4.3.4.4. Gout

Four individuals had possible gout. All cases were from sites at Driffield Terrace, and have not been observed by the author of this study, and thus, remain unconfirmed. Table 4.61 shows TPR of (possible) gout according to skeletal element. All skeletal elements not included in Table 4.61 have a TPR of 0%.

Element	Total Ind. Affected	Total Elements	Total Elements Affected	L	R	U	L TPR%	R TPR%	Total TPR%
Tarsal	1	1186	1	0	1		0.00	0.17	0.08
Metatarsal	4	978	4	3	1		0.62	0.21	0.41
Proximal Phalanx (Foot)	1	532	1	0	0	1	0.00	0.00	0.19

Table 4.61: TPR of gout per affected skeletal element

Table 4.61 shows that observed lesions possibly indicative of gout are most prevalent in the metatarsals (two examples in the first metatarsals, and one each in the fourth and fifth metatarsals). No significant difference in prevalence was found between left and right sides. Although archaeological examples of gout in bones other than the first metatarsal are extremely uncommon, the distribution still fits within the broad clinical distribution of gouty lesions. Prevalence per element is extremely low, but this is likely to be a result of the recording method utilised for foot bones in this study; in order to accommodate differential recording methods in collected osteological reports, tarsals and metatarsals were grouped together respectively, as opposed to recording the presence of each individual bone. Had each individual bone been recorded and counted, prevalence of gout per element would undoubtedly be slightly higher.

	Total No. Individuals	Total Affected	M	F	M CPR%	F CPR%	Total CPR%	Reference
York*	785	4	4	0	1.36	0.00	0.51	This study
Ancaster	327	0	0	0	0.00	0.00	0.00	Cox, 1989
Cirencester	424	3	3	0	1.22	0.00	0.71	McWhirr *et al.*, 1982: 191
Colchester	733	0	0	0	0.00	0.00	0.00	Crummy *et al.*, 1993
Derby	112	0	0	0	0.00	0.00	0.00	Wheeler, 1985
Dorchester	1511	5	3	2	0.68	0.43	0.33	Farwell and Molleson, 1993: 192-4; Davies *et al.*, 2002; Egging Dinwiddy, 2009
Dunstable	112	0	0	0	0.00	0.00	0.00	Matthews, 1981
Gloucester*	166	2	1	0	1.61	0.00	1.20	Simmonds *et al.*, 2008: 59-60
East London*	686	2	2	0	0.99	0.00	0.29	Barber and Bowsher, 2000: 286
Winchester	783	0	0	0	0.00	0.00	0.00	Booth *et al.*, 2010

Table 4.62: CPR of gout at York, comparative towns and Roman Britain

Table 4.62 shows CPR of gout in the York assemblage, comparative populations and Roman Britain. All sites marked with an asterisk (*) contain unconfirmed examples within the data. The results show that (if the observed cases are genuine) prevalence of gout in York fits well within the range observed at comparative sites. No significant difference in the prevalence of gout at York was found between sexes. A Fisher’s Exact test was performed to examine prevalence of gout across all populations. No significant difference was found between populations, or from expected values. These results indicate that prevalence of gout at the observed towns was consistently low.

4.3.4.5. Sacroiliac Fusion

One individual (a 40-44 year old male) had sacroiliac fusion that could be indicative of a number of pathological conditions. Fusion occurred in the left sacroiliac joint (Figure 4.31). Only the superior margin of the sacroiliac border appears to have fused, although fusion in this location is complete. No fusion or osteophytic “bridging” has occurred on the anterior or posterior sacroiliac margins.

Fusion of the sacroiliac joint is commonly an early feature of ankylosing spondylitis, though fusion of this joint is also found in other conditions such as Diffuse Idiopathic Skeletal Hyperostosis (DISH), and also severe osteoarthritis (Waldron and Rogers, 1990; Aufderheide and Rodríguez-Martin, 1998: 97-99 and 102-3; Cox and Mays, 2000: 175-6; Dar *et al.*, 2005). Sacroiliac fusion, DISH and ankylosing spondylitis are all more common in older males (Stewart, 1984; Waldron and Rogers, 1990: 126; Aufderheide and Rodríguez-Martin, 1998: 97-99; Cox and Mays, 2000: 170-1 and 176); so this individual fits the expected demographic for both specific conditions. Unfortunately, the evidence from this individual is very limited because only the sacrum and the left side of the pelvis were present. However, sacroiliac fusion that is limited to the superior border is more typical of DISH; in ankylosing spondylitis, fusion tends to involve the whole joint surface (Cox and Mays, 2000: 176). This may suggest that this individual is exhibiting a case of DISH. However, the limited nature of the evidence means that this case cannot be conclusively classified as one specific condition.

Whatever the case, CPR of sacroiliac fusion is low, calculated at 0.13%. No other cases of DISH or ankylosing spondylitis were observed in the York assemblage. CPR of DISH in Roman Britain has been calculated at 1.3% (Roberts and Cox, 2003: 139). If this case is representative of DISH, prevalence of the condition in Roman York is lower than expected. No CPR was available for ankylosing spondylitis.

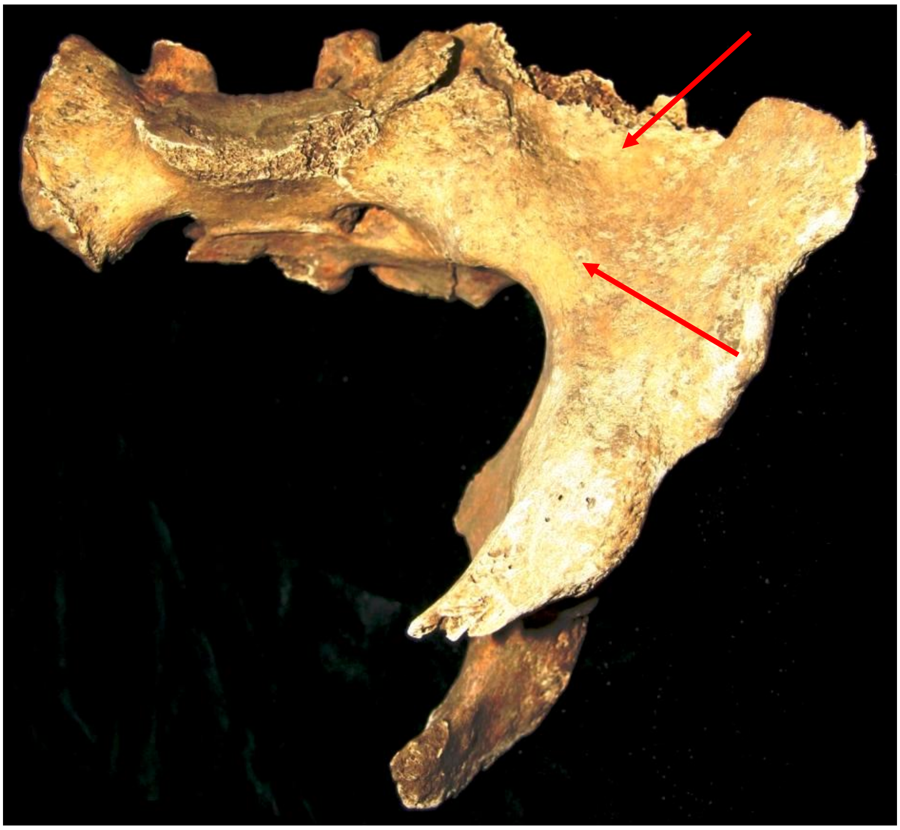

Figure 4.31: Fusion of superior left sacroiliac border of SK NHM/Wenham 69, Trentholme Drive (McIntyre 2011)

4.3.4.6. Summary: Joint Disease

To summarise, Figure 4.32 shows the prevalence distribution of all types of observed joint disease across all sites.

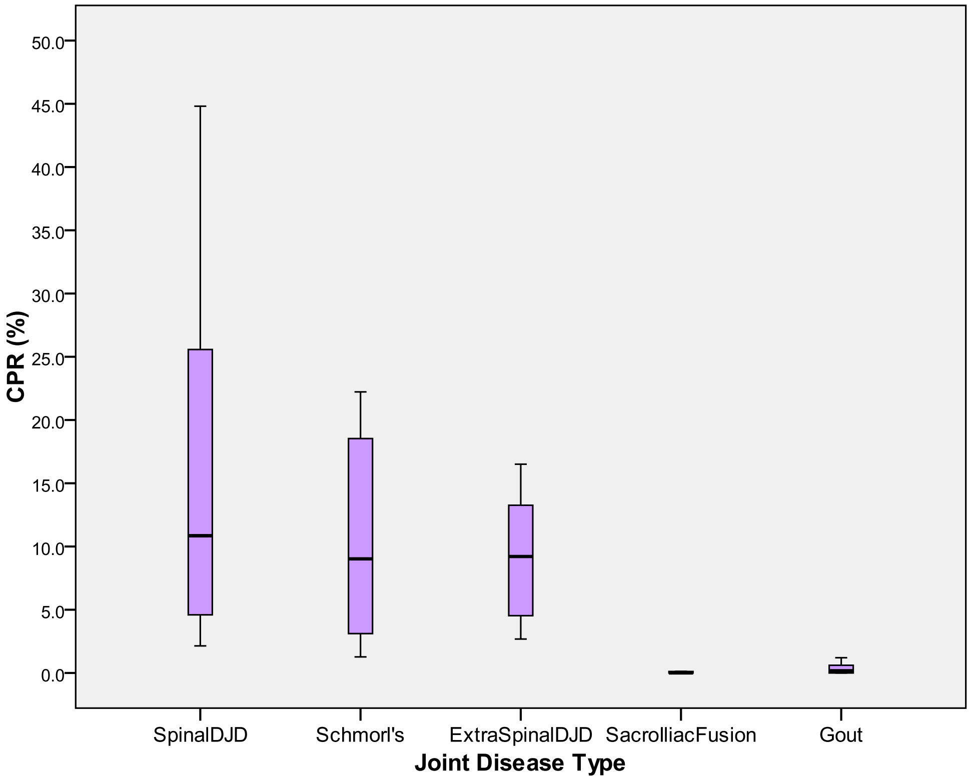

Figure 4.32: Crude distribution of joint disease across all towns

Figure 4.32 shows that the York population fits comfortably within each of the different joint disease distributions. Overall prevalence of spinal joint disease, Schmorl's nodes and extra-spinal joint disease varies quite widely between populations, although median prevalence values are around the 10% mark for all three conditions. Prevalence of these three pathological conditions is, therefore, likely to vary widely amongst Romano-British urban populations. Prevalence ranges for sacroiliac fusion and gout, however, have much narrower distributions, indicating that prevalence of either of these conditions at Romano-British towns is likely to be consistently very low.

4.3.5. Infectious Disease

This section includes evidence of tuberculosis, brucellosis, maxillary sinusitis, osteomyelitis, osteitis, periostitis and other manifestations of non-specific infection. No other specific infectious disease such as treponemal disease, and leprosy was observed.

4.3.5.1. Tuberculosis

Tuberculosis is a chronic or acute infection of the soft and skeletal tissue (Aufderheide and Rodríguez-Martin, 1998: 118). Skeletal manifestations of tuberculosis usually represent individuals with the secondary stage of the disease. More than 40% of cases of skeletal tuberculosis involve the spine, though other commonly affected areas include the joints, metaphyses and ribs (Aufderheide and Rodríguez-Martin, 1998: 134). Two adult individuals from the York assemblage had possible gastro-intestinal tuberculosis; these have not been observed by the author of this study, and thus, remain unconfirmed. Table 4.63 shows TPR of affected skeletal elements. All skeletal elements not included in Table 4.63 have a TPR of 0%.

Element	Total Elements	Total Affected	L	R	L TPR%	R TPR%	Total TPR%
L3	147	1					0.68
L4	152	1					0.66
L5	152	1					0.66
S1	151	1					0.66
Pelvis	384	3	2	1	1.07	0.55	0.78

Table 4.63: TPR of tuberculosis per affected skeletal element

TPR of tuberculosis in the above elements is low, and that skeletal involvement is limited to the lower lumbar/first sacral vertebra and the pelvis.

	Total No. Individuals	Total Affected	M	F	M CPR %	F CPR %	Total CPR %	Reference
York*	785	2	2	0	0.68	0.00	0.25	This study
Ancaster	327	2	1	1	0.78	1.20	0.61	Cox, 1989: 34-6
Cirencester*	424	1	1	0	0.41	0.00	0.24	McWhirr *et al.*, 1982: 181
Colchester	733	0					0.00	Crummy *et al.*, 1993
Derby	112	0					0.00	Wheeler, 1985
Dorchester	1511	4	2	2	0.45	0.43	0.26	Farwell and Molleson, 1993: 190; Davies *et al.*, 2002: 153; Egging Dinwiddy, 2009
Dunstable*	112	1	1	0	2.17	0.00	0.89	Matthews, 1981: 40
Gloucester	166	0					0.00	Simmonds *et al.*, 2008
London	869	2	0	0	0.00	0.00	0.23	Barber and Bowsher, 2000: 287; MOLA Centre for Human Bioarchaeology, 2009a; MOLA Centre for Human Bioarchaeology, 2009b
Winchester	783	0					0.00	Booth *et al.*, 2010
Roman Britain	2427	11	6	5			0.45	Roberts and Cox, 2003: 120

Table 4.64: CPR of tuberculosis at York, comparative towns and Roman Britain

Table 4.64 shows CPR of tuberculosis in the York assemblage, comparative populations and Roman Britain. All sites marked with an asterisk (*) contain unconfirmed examples within the data. The results show that prevalence of tuberculosis at the observed sites is up to 1%, and therefore extremely low. Prevalence at York is slightly lower than the calculated rate for Roman Britain. A Fisher's Exact test was performed to examine prevalence of tuberculosis across all populations. No significant difference was found between populations, or from expected values. No significant difference was found in the sex distribution of tuberculosis in the York assemblage.

4.3.5.2. Brucellosis

Brucellosis is an acute zoonotic infection that can be transmitted to humans by eating infected animal products (e.g. milk, cheese, yoghurt), or by bacteria from infected animals permeating the skin (e.g. cuts/abrasions coming into contact with infected animal tissue, possibly during animal husbandry (Young, 1995; Corbel, 1997; Aufderheide and Rodríguez-Martin, 1998: 192; Capasso, 1999; Donoghue, 2008: 161). Animals that can carry and transmit the disease include sheep, goats, cows, pigs, horses and camels (Young, 1995; Corbel, 1997; Aufderheide and Rodríguez-Martin, 1998: 192). Approximately 10% of modern cases of brucellosis involve skeletal elements (Aufderheide and Rodríguez-Martin, 1998: 192).

One case of possible brucellosis was observed in an older adult female. The only skeletal elements involved were both ilia of the pelvis, giving a TPR of 0.52%. Post-depositional damage to the affected bones meant that this case could not be confirmed (Holst, 2010: 4). Alternative proposed diagnoses include tuberculosis and osteomyelitis (Holst, 2010: 6).

No other cases of brucellosis (possible or confirmed) were found in any of the comparative sites used in this study. Brucellosis is rarely reported in palaeopathological literature (Ortner, 2003).

4.3.5.3. Maxillary Sinusitis

Seven individuals from York were observed with maxillary sinusitis. Table 4.65 shows TPR of affected skeletal elements. All skeletal elements not included in Table 4.65 have a TPR of 0%.

	Total Elements	Total Affected	L	R	L TPR%	R TPR%	Total TPR%
Maxilla	507	11	4	7	1.55	2.83	2.17

Table 4.65: TPR of maxillary sinusitis per affected skeletal element

TPR of maxillary sinusitis was low. The right side was involved in all affected individuals, although no significant difference was found in prevalence of maxillary sinusitis according to side.

	Total No. Individuals	Total Affected	M	F	M CPR %	F CPR %	Total CPR %	Reference
York	785	7	4	2	1.36	1.28	0.89	This study
Ancaster	327	0					0.00	Cox, 1989
Cirencester	424	7	4	3	1.63	3.00	1.65	McWhirr *et al.*, 1982: 181
Colchester	733	10	5	5	2.76	2.82	1.36	Crummy *et al.*, 1993: 79
Derby	112	0					0.00	Wheeler, 1985
Dorchester	1511	1	1	0	0.23	0.00	0.07	Farwell and Molleson, 1993; Davies *et al.*, 2002; Egging Dinwiddy, 2009: 22
Dunstable	112	0					0.00	Matthews, 1981
Gloucester	166	3	1	1	1.61	4.00	1.81	Simmonds *et al.*, 2008: 51
London	869	5	3	2	1.20	1.11	0.58	Barber and Bowsher, 2000; MOLA Centre for Human Bioarchaeology 2009a; MOLA Centre for Human Bioarchaeology 2009b
St. Albans	27	0	0	0			0.00	McKinley, 1992
Winchester	783	26	12	14	5.61	6.42	3.32	Booth *et al.*, 2010: 385-6
Roman Britain	2013	36	20	12			1.79	Roberts and Cox, 2003: 113

Table 4.66: CPR of maxillary sinusitis at York, comparative towns and Roman Britain

Table 4.66 shows CPR of maxillary sinusitis in the York assemblage, comparative populations and Roman Britain. As expected, observed prevalence of maxillary sinusitis at York is lower than predicted for the period by Roberts and Cox (2003), and is also lower than all other observed rates except for those at Dorchester and London. A Fisher's Exact test was performed to examine prevalence of maxillary sinusitis across all observed populations. The results were significant (Fisher's Exact=52.28, p=<0.01), indicating that prevalence of maxillary sinusitis is significantly different from expected values.

Further Fisher's Exact testing showed that observed prevalence of this condition was not significantly different from expected values when data from Dorchester and Winchester were removed (Fisher's Exact=10.89, p=0.14). This suggests that data from Dorchester and Winchester had skewed the original Fisher's Exact test results. Observed results at all other sites were therefore not significantly different from expected values. These results indicate that observed prevalence at Dorchester was significantly lower than expected. At Winchester, observed prevalence was significantly higher than expected. Additionally, no significant difference was found in the distribution of maxillary sinusitis at York according to sex.

4.3.5.4. Non-Specific Infection

Tables 4.67-4.70 show TPR of periosteal new bone, osteitis, osteomyelitis and miscellaneous non-specific infection of affected skeletal elements. Skeletal elements were excluded from these tables if they had a TPR of 0%.

Periosteal New Bone

Table 4.67 shows that the most frequently and prevalently affected bone is the tibia. The tibia is known to be frequently affected by periosteal new bone formation; this may be related to the soft tissue layers on the anterior tibia being very thin, hence the surface of the bone is closer to the skin and more prone to inflammation subsequent to irritation of the skin (Brothwell, 1981; Cox and Mays, 2000: 147; Ortner, 2008: 196; Weston, 2008: 48). Higher prevalence in the coccyx is likely to be due to the small sample size. Higher prevalence in the fibula is partially related to cases where the tibia was initially involved and the condition has been exacerbated, spreading to the adjacent fibula; five of the 12 fibulae with periosteal new bone also had an affected tibia from the same limb. Like the tibia, the fibula is also known to be affected frequently by infective lesions in the early historic period (Brothwell, 1981).

Element	Total Elements	Total Elements Affected	L	R	U	L TPR%	R TPR%	Total TPR%
Parietal	603	2	1	1		0.34	0.33	0.33
Occipital	303.5	1						0.33
Sphenoid	258.5	1						0.39
Ribs	2957	9	2	7		0.14	0.50	0.30
Humerus	656	4	2	1	1	0.64	0.31	0.61
Ulna	595	6	3	3		1.04	1.01	1.01
Radius	599	4	2	2		0.65	0.71	0.67
Metacarpals	1109	2	1	1		0.19	0.17	0.18
Ilium	384	4	2	2		1.07	1.09	1.04
Ischium	348	1	1	0		0.57	0.00	0.29
Sacrum	151	1						0.66
Coccyx	23	1						4.35
Femur	736	7	2	5		0.56	1.44	0.95
Tibia	592	35	17	18		5.72	6.52	5.91
Fibula	494	12	9	3		3.98	1.26	2.43
Tarsals	1108	1	0	1		0.00	0.17	0.09
Metatarsals	978	4	1	3		0.21	0.62	0.41
Proximal phalanges (Foot)	532	3	2	1		0.82	0.40	0.56

Table 4.67: TPR of periosteal new bone formation per affected skeletal element

Osteitis

Element	Total Elements	Total Elements Affected	L	R	L TPR%	R TPR%	Total TPR%
Tibia	592	2	1	1	0.34	0.36	0.34

Table 4.68: TPR of osteitis per affected skeletal element

Table 4.68 shows that evidence of osteitis was only found in two tibiae, therefore TPR was very low. Both bones were from the same site (Mill Mount: Field Archaeology Specialists, 2005a), but were not from the same individual. These lesions may be the result of soft tissue injury or some other event that led to the formation of a haematoma under the skin (Field Archaeology Specialists, 2005a: Lviii).

Osteomyelitis

Element	Total Elements	Total Elements Affected	L	R	L TPR%	R TPR%	Total TPR%
Humerus	656	1	0	1	0.00	0.31	0.15
Ulna	595	1	1	0	0.35	0.00	0.17

Table 4.69: TPR of osteomyelitis per affected skeletal element

Table 4.69 shows that prevalence of osteomyelitis was also very low and only located in bones of the arm. The bones are from two different individuals from two different sites. This distribution of osteomyelitis is slightly unusual; osteomyelitis is most common in the femur and tibia (Roberts and Manchester, 1995: 129).

Miscellaneous Non-Specific Infection

Table 4.70 shows that the TPR of “miscellaneous” non-specific infection is highest in the tibia and fibula. As previously discussed, this is to be expected as infectious lesions like these are most commonly found in these two bones. This also mirrors the results found for the distribution of periosteal new bone.

Element	Total Elements	Total Elements Affected	L	R	U	L TPR%	R TPR%	Total TPR%
Parietal	603	6	3	3		1.01	1.00	1.00
Occipital	303.5	1						0.33
Maxilla	507	4	2	2		0.77	0.81	0.79
Sphenoid	258.5	1						0.39
Ribs	2957	30	15	15		1.01	1.06	1.01
Clavicle	478	1	0	1		0.00	0.43	0.21
Scapula	311	2	0	2		0.00	1.32	0.64
Humerus	656	3	1	2		0.32	0.62	0.46
Ulna	595	2	2	0		0.69	0.00	0.34
Radius	599	2	0	2		0.00	0.71	0.33
Ilium	384	1	1	0		0.53	0.00	0.26
Femur	736	7	2	5		0.56	1.44	0.95
Tibia	592	16	7	9		2.36	3.26	2.70
Fibula	494	12	7	4	1	3.10	1.67	2.43
Metatarsals	978	2	0	2		0.00	0.41	0.20

Table 4.70: TPR of miscellaneous non-specific infection per affected skeletal element

Table 4.71 shows CPR of non-specific infection in the York assemblage and comparative populations. Roman Britain was not included as only data for osteomyelitis was available in Roberts and Cox (2003: 127). All four types of non-specific infection were combined for all populations.

Compared to the other observed populations, York has the third highest prevalence of non-specific infection. A Fisher’s Exact test was performed to examine prevalence of non-specific infection across all observed populations. The results were significant (Fisher’s Exact=258.05, p=<0.01), indicating that prevalence of non-specific infection is significantly different from expected values. Further testing suggested that no single population was responsible for skewing the results of the first Fisher’s Exact test. These results, coupled with the raw data observed in Table 4.71, and also the wider prevalence range displayed in Figure 4.33 (page 231) suggest that the range of non-specific infection in skeletal samples from urban sites in Roman Britain is highly variable. The observed prevalence ranges are likely to be the result of complex etiological factors related to settlement type, population density and so on.

	Total No. Individuals	Total Affected	M	F	M CPR %	F CPR%	Total CPR%	Reference
York	785	84	41	11	13.95	7.05	10.70	This study
Ancaster	327	12	11	2	8.53	2.41	3.67	Cox, 1989: 36-9
Cirencester	424	30	21	8	8.57	8.00	7.08	McWhirr *et al.*, 1982: 182-3
Colchester	733	15	10	2	5.52	1.13	2.05	Crummy *et al.*, 1993: 8, 16-19, 33 and 77
Derby	112	3	3	0	15.79	0.00	2.68	Wheeler, 1985: 339
Dorchester	1511	31	15	16	3.41	3.44	2.05	Farwell and Molleson, 1993: 185; Davies *et al.*, 2002: 153; Egging Dinwiddy, 2009: 26-7
Gloucester	166	55	21	10	33.87	40.00	33.13	Simmonds *et al.*, 2008: 50-2, 61
London	183	52	14	6	30.43	18.75	28.42	Barber and Bowsher, 2000: 274; MOLA Centre for Human Bioarchaeology, 2009a; MOLA Centre for Human Bioarchaeology, 2009b
St. Albans	27	0					0.00	McKinley, 1992
Winchester	783	27	12	8	5.61	3.67	3.45	Booth *et al.*, 2010: 383-5

Table 4.71: CPR of non-specific infection at York and comparative towns

A chi-square test was performed in order to examine prevalence of non-specific infection according to sex in the York sample. Results of the test showed that significantly more males than females were affected by non-specific infection (χ=4.74, p=0.03).

4.3.5.5. Summary: Infectious Disease

Figure 4.33 shows the prevalence distribution of all types of observed infectious disease across all populations. This figure shows that the York population fits comfortably within each of the different infectious disease prevalence distributions with the exception of the distribution for brucellosis, where York is an extreme outlier. This result is the consequence of the rarity of brucellosis in the archaeological record. Although this is not a confirmed case of the disease, brucellosis was present in the Roman Empire, and evidence for substantial rates of the infection have been found at Herculaneum (17.4% of adults - Capasso, 1999; Capasso, 2002). Considering that skeletal lesions only appear in approximately 10% of cases, the actual prevalence of brucellosis within the living population at Herculaneum is likely to be much larger (Aufderheide and Rodríguez-Martin, 1998: 192). The presence of brucellosis in the Empire, in addition to the rather fluid nature of trade and migration in the Empire and Roman Britain mean that the York example could genuinely be a Romano-British case of brucellosis.

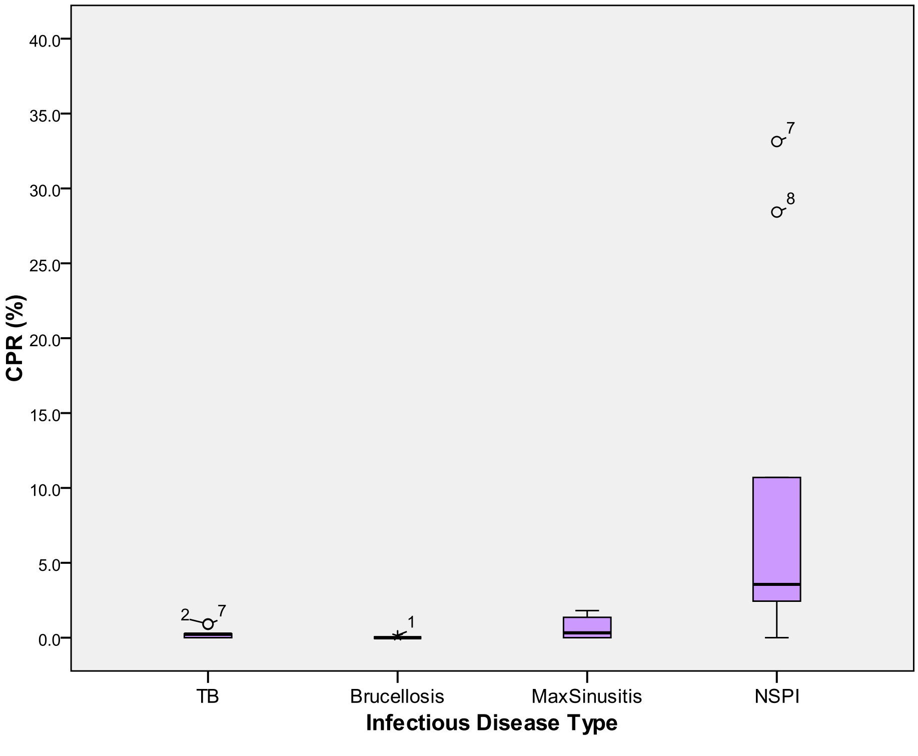

Figure 4.33: Crude distribution of infectious disease across all towns. *1 represents an extreme outlaying value for brucellosis at York, O2 and O7 represent outlaying values for tuberculosis at Ancaster and Dunstable respectively, and O7 and O8 represent outlaying values for non-specific infectious disease at Gloucester and London respectively

Overall, the observed prevalence range of specific infectious disease is very low across all populations; conversely observed prevalence range of non-specific infection is much larger (although the median value is still <5%). Furthermore, Ancaster and Dunstable have been marked as having higher rates of tuberculosis. However, these rates are not significantly different from expected values, and may represent an anomaly in the number of observed cases in two of the smaller samples in this study. Gloucester and London have anomalously high rates of non-specific infection. York is located towards the top end of the expected prevalence range. These results may be related to the settlement type and associated factors (e.g. population density).

4.3.6. Metabolic Disease and Deficiency

This section includes evidence of osteopenia, osteoporosis, cribra orbitalia and porotic hyperostosis. No other metabolic disease such as scurvy, rickets, osteomalacia, and hyperostosis frontalis interna (HFI) were observed.

4.3.6.1. Osteopenia

Osteopenia is a pathological condition whereby bone mineral density is lower than normal, and can develop into osteoporosis (McIlwain *et al.*, 2004; Burgener *et al.*, 2006). Description and diagnosis of osteopenia and osteoporosis is complex, and frequently overlaps (Burgener *et al.*, 2006: 3, 136-7; Jergas, 2008: 77; Vigorita *et al.*, 2008: 111). One possible case of osteopenia was observed, in an adult female from the Bar Convent. Loss of horizontal trabeculae was observed in the pelvis and both femora of this individual. This case remains unconfirmed, as only 5% of the skeleton remained and the remaining elements were very fragmented. The observed fragility of the bones may have been related to post-depositional damage. Assuming that this is case is genuine, Table 4.72 shows TPR of osteopenia. Skeletal elements with a TPR of 0% were excluded from the table.

Element	Total Elements	Total No. Affected	L	R	L TPR%	R TPR%	Total TPR%
Pelvis	384	2	1	1	0.53	0.55	0.52
Femur	736	2	1	1	0.28	0.29	0.27

Table 4.72: TPR of osteopenia per affected skeletal element

Osteopenia can occur as a localised or generalised condition. Unfortunately, as very little of this individual remained, it is impossible to distinguish which form of the condition was present. Table 4.72 shows that, whatever the case, TPR for both affected skeletal elements is very low. No other comparative sites in this study had observed cases of osteopenia. As only one individual from the York assemblage had (possible) osteopenia, CPR was calculated at 0.13%. No prevalence data was available for Roman Britain.

4.3.6.2. Osteoporosis

The aetiology of osteoporosis is extremely complex, with both genetic and lifestyle factors having influence over prevalence of the condition (Agarwal and Grynpas, 1996). The York assemblage had one possible case of osteoporosis, observed in all 24 vertebrae of one female aged over 40 years. No associated fractures were recorded. Table 4.73 shows TPR of osteoporosis per vertebra. All other skeletal elements had a TPR of 0%.

All vertebrae have a TPR of less than 1%, indicating extremely low prevalence of osteoporosis. When individuals are affected by osteoporosis, trabecular thinning (and loss) may also occur in the long bone metaphyses (Aufderheide and Rodríguez-Martin, 1998: 315). The osteological notes for this skeleton do not mention reduction of bone mass in any of the long bones; furthermore, this individual does not have any reported fractures. Osteoporosis related bone fracture is likely to occur in the proximal femur and distal radius (Aufderheide and Rodríguez-Martin, 1998: 315; Samelson and Hannen, 2006: 76). Conversely, this individual is an older adult female, which does fit with the expected demographic for osteoporosis (Riggs and Melton, 1995; Aufderheide and Rodríguez-Martin, 1998: 314-6; Samelson and Hannen, 2006). Without further evidence or access to the individual for more detailed observation, this case can only be classified as a possible case of osteoporosis.

Element	Total Present	Total Affected	TPR%
C1	146	1	0.68
C2	135	1	0.74
C3	127	1	0.79
C4	117	1	0.85
C5	120	1	0.83
C6	122	1	0.82
C7	126	1	0.79
T1	140	1	0.71
T2	140	1	0.71
T3	141	1	0.71
T4	142	1	0.70
T5	145	1	0.69
T6	146	1	0.68
T7	139	1	0.72
T8	141	1	0.71
T9	144	1	0.69
T10	140	1	0.71
T11	141	1	0.71
T12	136	1	0.74
L1	146	1	0.68
L2	148	1	0.68
L3	147	1	0.68
L4	152	1	0.66
L5	152	1	0.66

Table 4.73: TPR of osteoporosis per affected vertebra

Table 4.74 shows CPR of osteoporosis in the York assemblage, comparative populations and Roman Britain in general. Data for York includes possible cases. York has the lowest prevalence of (possible) osteoporosis of all the sites where osteoporosis was present, although prevalence was extremely low across all populations.

A Fisher's Exact test was performed to examine prevalence of osteoporosis in York and across all observed towns. The results were significant (Fisher's Exact=63.14, p=<0.01), indicating that overall prevalence of osteoporosis is significantly different from expected values. As there are only three towns in total (York, Ancaster and Dorchester) that show any variation at all (with all other sites having zero examples), the significant difference may be related to unquantifiable factors related to each town. For example, Mays' (2006b) study of the Ancaster population suggested that prevalence at Ancaster was anomalously high; it was suggested that rates of osteoporosis in the past should approximate rates found in modern populations. Mays (2006b: 526) suggested that the elevated prevalence at Ancaster may have at least partially been due to the small sample size in the study. Unfortunately, the complex aetiology of osteoporosis coupled with the limited archaeological data available for the given examples of affected skeletal material makes it difficult to pinpoint the exact reasons for the prevalence differences.

	Total No. Individuals	**Total Affected**	**M**	**F**	**M CPR %**	**F CPR %**	**Total CPR %**	**Reference**
York	785	1	0	1	0.00	0.64	0.13	This study
Ancaster	327	6	0	1	0.00	1.20	1.83	Cox, 1989: 67
Cirencester	424	0					0.00	McWhirr *et al.*, 1982
Colchester	733	0					0.00	Crummy *et al.*, 1993
Derby	112	0					0.00	Wheeler, 1985
Dorchester	1511	31	8	23	1.82	4.95	2.05	Farwell and Molleson, 1993: 194; Davies *et al.*, 2002; Egging Dinwiddy, 2009: 23
Dunstable	112	0					0.00	Matthews, 1981
Gloucester	166	0					0.00	Simmonds *et al.*, 2008
London	869	0					0.00	Barber and Bowsher, 2000: 287; MOLA Centre for Human Bioarchaeology, 2009a; MOLA Centre for Human Bioarchaeology, 2009b
Winchester	783	0					0.00	Booth *et al.*, 2010
Roman Britain	1732	45	13	32			2.60	Roberts and Cox, 2003: 143

Table 4.74: CPR of osteoporosis at York, comparative towns and Roman Britain

4.3.6.3. Cribra Orbitalia and Porotic Hyperostosis

Cribra orbitalia manifests as small lesions in the orbital roof, with 90% of cases being bilateral (Ortner, 2003: 102). Porotic hyperostosis is similar in appearance, but is located on the outer table of the parietal and frontal bones (and occasionally the occipital; Ortner, 2003: 102). Both conditions predominantly occur in infants and young children but are also visible as inactive or “healed” (i.e. remodelled) lesions in adults (Ortner, 2003: 102). The exact aetiology of cribra orbitalia and porotic hyperostosis is unknown, though both have been linked to a number of conditions including iron deficiency anaemia, infection and vitamin deficiency (porotic hyperostosis is often found in conjunction with evidence for scurvy or rickets; Ortner, 2003; 102-6; Steckel *et al.*, 2006: 13). More recent research has postulated Vitamin B deficiency as a possible cause (Walker *et al.*, 2009). However, when only observed macroscopically, cribra orbitalia and porotic hyperostosis are best used only as general indicators of stress (Steckel *et al.*, 2006).

Table 4.75 shows TPR of cribra orbitalia. Table 4.76 shows TPR of porotic hyperostosis.

Total Orbits	Affected Orbits	L	R	Total TPR%
553	71	30	41	12.84

Table 4.75: TPR of cribra

Element	Total No. Affected	L	R	L TPR%	R TPR%	Total TPR%
Parietal	82	40	41	13.49	13.64	13.60
Frontal	13					4.38
Occipital	11					3.62

Table 4.76: TPR of porotic hyperostosis per affected skeletal element

Table 4.75 shows that porotic hyperostosis is most prevalent in the parietals, then the frontal and occipital. This matches the expected distribution of the lesions

(Walker, 1986: 345; Aufderheide and Rodríguez-Martin, 1998: 348; Ortner, 2003: 102-6). As well as these results, 11 individuals had both cribra orbitalia and porotic hyperostosis (CPR 1.4%). No significant difference in prevalence was found between left and right sides in either cribra orbitalia or porotic hyperostosis.

Table 4.77 shows CPR of cribra orbitalia in the York assemblage, comparative populations and Roman Britain. Sites marked with an asterisk (*) include possible cases. The six cases from Dunstable included in Table 4.77 were recorded as “supraorbital osteoporosis”. York has relatively low prevalence of cribra orbitalia when compared to rates from other sites and the calculated rate for Roman Britain. A Fisher’s Exact test was performed to examine prevalence of cribra orbitalia across all observed populations. The result was significant (Fisher’s Exact=272.09, p=<0.01), indicating that prevalence of cribra orbitalia is significantly different from expected values. A second test was performed, excluding the St. Albans data, in order to ascertain whether the smaller sample with 100% prevalence had skewed the results of the original test. However, the result of this second test was still highly significant (Fisher’s Exact=142.51, p=<0.01), indicating that prevalence of cribra orbitalia was still significantly different from expected values even when the St. Albans data was not included. It should be noted that the 100% prevalence rate observed at St. Albans may be due to a combination of higher prevalence and smaller sample size.

Further testing indicated that no single population was responsible for the difference from expected values. These results, combined with the observed range and frequencies of cribra orbitalia demonstrated in Table 4.77 may indicate that overall prevalence of this pathological condition is variable during the Roman period in Britain. Values observed at York, when compared to the overall distribution (also shown in Figures 4.36 and 4.39, pages 242 and 255 respectively) appear to be at the lower end of the expected range. Furthermore, no significant difference was found in prevalence of cribra orbitalia according to sex in the York population.

	Total No. Individuals	Total Affected	M	F	M CPR%	F CPR%	Total CPR%	Reference
York	785	44	25	10	8.50	6.41	5.61	This study
Ancaster	327	39	18	8	13.95	9.64	11.93	Cox, 1989: 66
Cirencester	424	35	20	7	8.16	7.00	8.25	McWhirr *et al.*, 1982: 186-7
Colchester	733	27	6	6	3.31	3.39	3.68	Crummy *et al.*, 1993: 19 and 87
Derby	112	0					0.00	Wheeler, 1985
Dorchester	1511	223	65	82	14.77	17.63	14.76	Farwell and Molleson, 1993: 185; Davies *et al.*, 2002: 153; Egging Dinwiddy, 2009: 30
Dunstable*	112	6					5.36	Matthews, 1981: Table 9 (Appendix)
Gloucester	166	19	4	2	6.45	8.00	11.45	Simmonds *et al.*, 2008: 52-3, 62-3
London	869	54	17	9	6.83	5.00	6.21	Barber and Bowsher, 2000: 285; MOLA Centre for Human Bioarchaeology, 2009a; MOLA Centre for Human Bioarchaeology, 2009b
St. Albans	27	27	3	3	30.00	50.00	100.00	McKinley, 1992
Winchester	783	40	9	18	4.21	8.26	5.11	Booth *et al.*, 2010: 392-3
Roman Britain	4773	460	161	144			9.64	Roberts and Cox, 2003: 141

Table 4.77: CPR of cribra orbitalia at York, comparative towns and Roman Britain

Table 4.78 shows CPR of porotic hyperostosis in the York assemblage and comparative sites. Data was not available for Roman Britain. The results show that observed prevalence of porotic hyperostosis at York is more than five times higher than in the comparative populations. Porotic hyperostosis was only observed in two of the comparative populations, and in a very small number of individuals. A Fisher's Exact test was performed to examine prevalence of porotic hyperostosis across all observed populations. The result was significant (Fisher's Exact=139.87, p=<0.01), indicating that observed prevalence of porotic hyperostosis is significantly different from expected values. Further testing indicated that although the results of the first test were not completely skewed by a single population, they were affected substantially by the observed result at York: when the York data was excluded and the test performed again, results were still significant but to a much lesser extent (Fisher's Exact=14.36, p=0.01). No significant difference was found between populations only when data from both York and Ancaster were excluded (Fisher's Exact=10.23, p=0.68). However, this may be expected, as prevalence at every other remaining town except London (which only exhibits one case of porotic hyperostosis) has zero prevalence.

	Total No. Individuals	**Total Affected**	**M**	**F**	**M CPR%**	**F CPR%**	**Total CPR%**	**Reference**
York	785	42	27	9	9.18	5.77	5.35	This study
Ancaster	327	3	1	0	0.78	0.00	0.92	Cox, 1989: 66
Cirencester	424	0					0.00	McWhirr *et al.*, 1982
Colchester	733	0					0.00	Crummy *et al.*, 1993
Derby	112	0					0.00	Wheeler, 1985
Dorchester	1511	0					0.00	Farwell and Molleson, 1993; Davies *et al.*, 2002; Egging Dinwiddy, 2009
Dunstable	112	0					0.00	Matthews, 1981
Gloucester	166	0					0.00	Simmonds *et al.*, 2008
London	869	1	0	1	0.00	0.56	0.12	Barber and Bowsher, 2000; MOLA Centre for Human Bioarchaeology, 2009a; MOLA Centre for Human Bioarchaeology, 2009b
Winchester	783	0					0.00	Booth *et al.*, 2010

Table 4.78: CPR of porotic hyperostosis at York and comparative towns

The majority of variation away from expected values therefore appears to be caused by the population from York, suggesting that prevalence of porotic hyperostosis in this population is significantly higher than expected. Further evidence of this is shown in Figure 4.36 (page 242), where York (and Ancaster) are extreme outliers outside the observed prevalence range for this pathological condition. Additionally, no significant difference in prevalence was observed at York according to sex.

The lower CPRs observed at sites other than York may reflect genuinely low prevalence/absence of porotic hyperostosis at these sites. Alternatively, it is possible that cases of porotic hyperostosis are being either missed by osteologists, or inconsistently diagnosed. Jacobi and Danforth (2002) demonstrated that there is inconsistency in the diagnosis and identification of porotic hyperostosis by osteologists, particularly where a skeleton exhibits a slight to moderate case. Different recording methods for porotic hyperostosis have suggested various means of scoring the associated lesions, based on the presence of porous lesions (e.g. El-Najjar *et al.*, 1976), the severity of the condition and/or degree of osteological expression (e.g. Angel, 1971; Stuart-Macadam, 1982; Buikstra and Ubelaker, 1994). Furthermore, cranial lesions on the ectocranial surface may be interpreted differentially as evidence of chronic scalp infection (Ortner, 2003: 102; Walker *et al.*, 2009: 109): heavily remodelled lesions of this type may not easily be distinguished from porotic hyporostosis.

In the present study, comparative assemblages were large enough that it would be expected that at least a few cases would be found. However, many of the examples observed in the York assemblage for this study were slight, and therefore extremely difficult to see, especially in cases where the characteristic "hair on end" lesions were heavily remodelled and the surface of the cranial vault was abraded or otherwise damaged. Examples of individuals with remodelled lesions are presented in Figures 4.34 and 4.35. These photos demonstrate that such lesions could be easy to miss osteologically. Alternatively, some of these lesions could be indicative of chronic scalp infection (Ortner, 2003: 102). If either of these scenarios applies to the comparative assemblages, observed rates at York may approximate genuine prevalence in the living population, rather than appearing anomalously high.

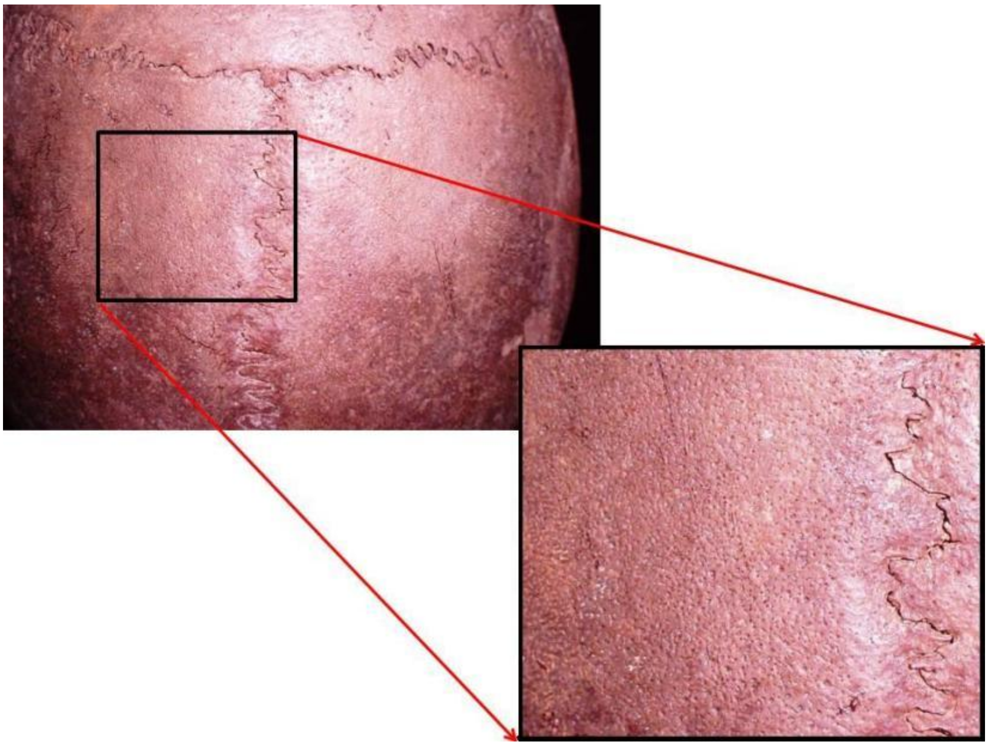

Figure 4.34: Highly remodelled porotic hyperostosis lesions on the cranium of SK 33173, 16-22 Coppergate (McIntyre, 2011)

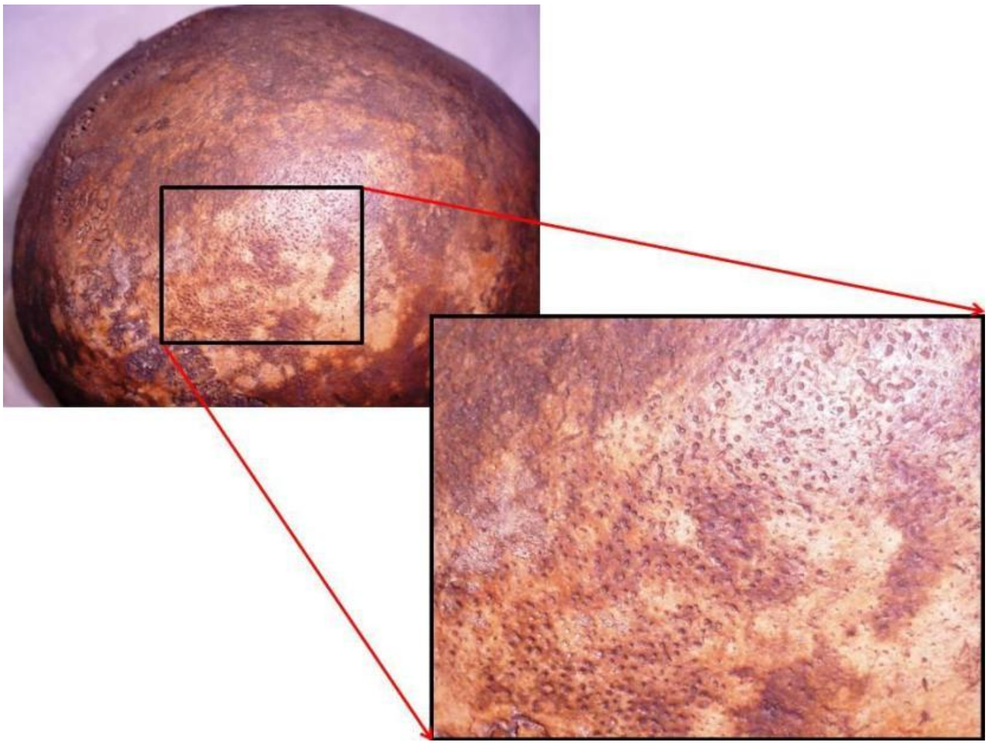

Figure 4.35: Remodelled porotic hyperostosis lesions on the cranium of LEEDM. D. T. 0945 (McIntyre, 2011)

4.3.6.4. Summary: Metabolic Disease and Deficiency

To summarise, Figure 4.36 shows the prevalence distribution of all types of observed metabolic disease across all populations.

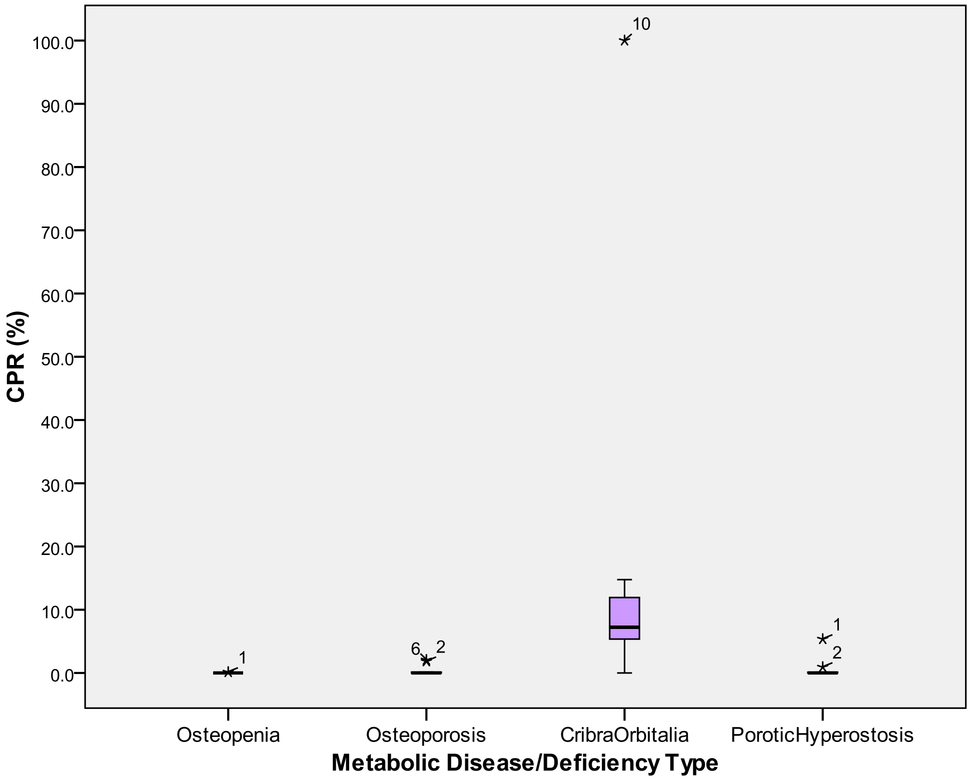

Figure 4.36: Crude prevalence distribution of metabolic disease/deficiency across all towns. *1 represents an extreme outlaying value at York. *2 represents extreme outlaying values at Ancaster, *6 represents extreme outlaying values at Dorchester, and *10 represents extreme outlaying values at St. Albans

Figure 4.36 suggests that prevalence of osteopenia, osteoporosis and porotic hyperostosis was consistently extremely low at towns in Roman Britain (although low rates of porotic hyperostosis may also reflect osteological observer error). Prevalence range for cribra orbitalia appears to be a lot more variable, although the median prevalence value is still rather low (<10%). These things considered, observed prevalence at York makes the site an extreme outlier for both osteopenia and porotic hyperostosis. Ancaster and Dorchester are extreme outliers for osteoporosis, with Ancaster also being an extreme outlier for porotic hyperostosis. St. Albans is also an extreme outlier for cribra orbitalia. Generally these results may suggest that populations occupying the observed sites were experiencing low levels of metabolic stress. With the exception of cribra orbitalia presence at St. Albans, even where sites are extreme outliers, their prevalence rates are still relatively low.

4.3.7. Neoplastic Conditions

This category of pathological condition includes evidence of “button” osteoma and osteochondroma. No evidence of other neoplastic conditions such as multiple myeloma or osteosarcoma was observed (0% prevalence).

4.3.7.1. “Button” Osteoma

Fourteen individuals from York had a single osteoma; a further four individuals had two or more. Two female individuals with multiple small osteomas were kept in a museum case at the Yorkshire Museum, and their position in the museum case meant that an exact osteoma count could not be made. A minimum estimate was therefore recorded for each individual.

Table 4.79 shows TPR of osteomas in the York assemblage. Skeletal elements not included in Table 4.79 have a TPR of 0%. As expected, the majority of osteomas were located on the frontal and parietals. Only four osteomas were observed in the post cranial skeleton. The location and distribution of osteomas in the York assemblage therefore fits the expected pattern. Table 4.80 shows CPR of osteomas in the York assemblage, comparative populations and Roman Britain.

Element	Total Elements	Total No. Affected	L	R	U	L TPR%	R TPR%	Total TPR%
Frontal	296.5	6						2.02
Parietal	603	5	4	1		1.35	0.33	1.69
Temporal	569	1	0	1		0.00	0.35	0.18
Maxilla	507	1	1	0		0.39	0.00	0.20
Mandible	265	1						0.38
Proximal Phalanx (Hand)	874	2	1	0	1	0.25	0.00	0.23
Femur	736	1	1	0		0.28	0.00	0.14
Tibia	592	1	0	0	1	0.00	0.00	0.17

Table 4.79: TPR of osteomas per affected skeletal element

	Total No. Individuals	Total Affected	M	F	M CPR%	F CPR%	Total CPR%	Reference
York	785	18	9	7	3.06	4.49	2.29	This study
Ancaster	327	8	7	1	5.43	1.20	2.45	Cox, 1989: 64
Cirencester	424	4	3	1	1.22	1.00	0.94	McWhirr *et al.*, 1982: 183
Colchester	733	5	3	2	1.66	1.13	0.68	Crummy *et al.*, 1993: 87
Derby	112	0					0.00	Wheeler, 1985
Dorchester	1511	4	3	1	0.68	0.22	0.26	Farwell and Molleson, 1993: 197; Davies *et al.*, 2002: 153; Egging Dinwiddy, 2009: 30
Dunstable	112	3	3	0	6.52	0.00	2.68	Matthews, 1981: Table 9 (Appendix)
Gloucester	166	3	1	1	1.61	4.00	1.81	Simmonds *et al.*, 2008: 61-2, 66
London	183	4	2	1	4.35	3.13	2.19	Barber and Bowsher, 2000; MOLA Centre for Human Bioarchaeology, 2009a; MOLA Centre for Human Bioarchaeology, 2009b
Winchester	783	5	2	3	0.93	1.38	0.64	Booth *et al.*, 2010: 393
Roman Britain	3033	32	24	7			1.06	Roberts and Cox, 2003: 114

Table 4.80: CPR of osteomas at York, comparative towns and Roman Britain

A Fisher's Exact test was performed to examine prevalence of osteoma across all observed sites. The result was significant (Fisher's Exact=35.949, p=<0.01), indicating that prevalence of osteoma is significantly different from expected values. Further testing showed that this cannot be attributed to one site alone, suggesting that prevalence of osteoma is variable. No significant difference was found between males and females from York.

4.3.7.2. Osteochondroma

One possible osteochondroma was observed, on the lateral midshaft left humerus of an adult possible male. TPR of osteochondroma was therefore calculated at 0.35% for the left humerus, with a total TPR of 0.15%. TPR for all other skeletal elements was 0%. These figures reflect the rarity of such pathological conditions in the archaeological record.

	Total No. Individuals	**Total Affected**	**M**	**F**	**M CPR%**	**F CPR%**	**Total CPR%**	**Reference**
York*	785	1	1	0	0.34	0.00	0.13	This study
Ancaster	327	0					0.00	Cox, 1989
Cirencester	424	0					0.00	McWhirr *et al.*, 1982
Colchester	733	0					0.00	Crummy *et al.*, 1993
Derby	112	2	1	1	5.26	3.45	1.79	Wheeler, 1985: 339
Dorchester	1511	0	0	0	0.00	0.00	0.00	Farwell and Molleson, 1993; Davies *et al.*, 2002; Egging Dinwiddy, 2009
Dunstable	112	0					0.00	Matthews, 1981
Gloucester	166	0					0.00	Simmonds *et al.*, 2008
London	869	0					0.00	Barber and Bowsher, 2000; MOLA Centre for Human Bioarchaeology, 2009a; MOLA Centre for Human Bioarchaeology, 2009b
Winchester	783	0					0.00	Booth *et al.*, 2010
Roman Britain	46	2					4.35	Roberts and Cox, 2003: 114

Table 4.81: CPR of osteochondroma at York, comparative towns and Roman Britain

Table 4.81 shows CPR of osteochondroma in the York assemblage, comparative populations and Roman Britain. Sites marked with an asterisk (*) include unconfirmed examples. The results show that prevalence of osteochondroma is again very low in the observed populations. It should be noted that the CPR calculated for Roman Britain by Roberts and Cox (2003: 114) is only based on data from one site (Derby Racecourse) which has a relatively small assemblage. This site (Derby Racecourse) is used as part of a comparative assemblage in the present study. The CPR of 4.35% calculated by Roberts and Cox (2003: 114) is therefore likely to be higher than genuine prevalence in the living population; incorporation of all known sites with 0% prevalence, as seen in Table 4.81 would bring this figure down to a (presumably) more representative figure.

A Fisher's Exact test was performed to examine prevalence of osteochondroma across all observed sites. The result was significant (Fisher's Exact=17.50, p=0.01), indicating that prevalence of osteochondroma is significantly different from expected values. Further testing showed that this result is skewed by anomalously higher than expected rates of osteochondroma at Derby. When data from Derby were excluded and the test performed again, observed rates at York and other comparative sites were not significantly different from expected values (Fisher's Exact=11.43, p=0.58).

4.3.7.3. Summary: Neoplastic Disease

To summarise, Figure 4.37 shows the prevalence distribution of all types of observed neoplastic disease across all populations.

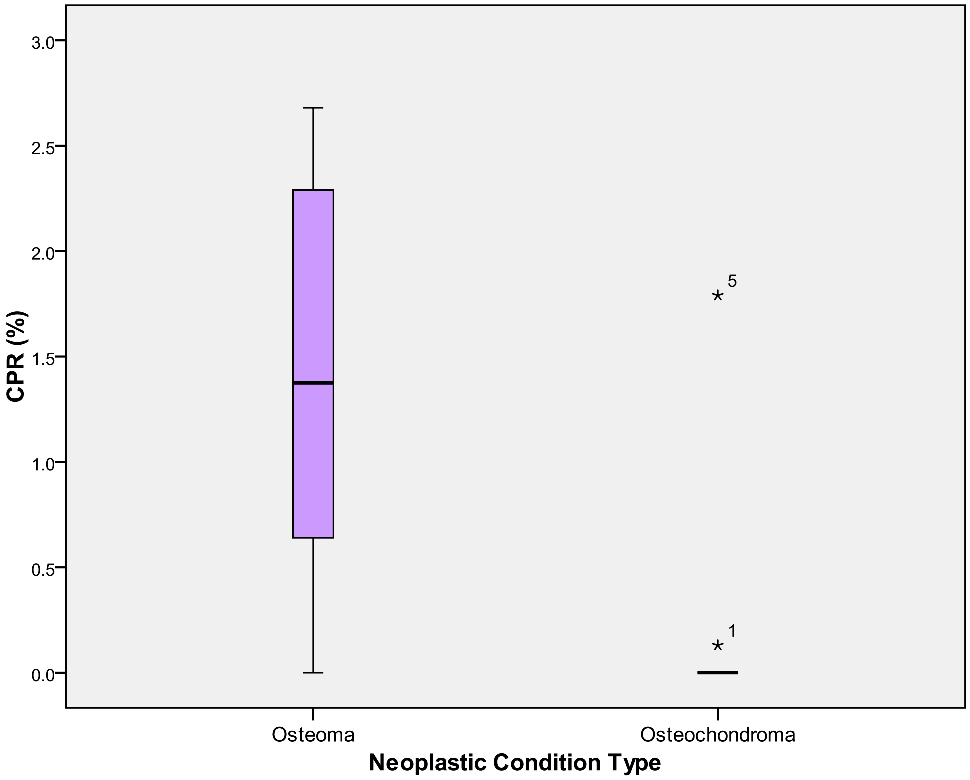

Figure 4.37: Crude distribution of neoplastic conditions across all towns. *1 represents an extreme outlaying value at York. *5 represents an extreme outlaying value at Derby

Prevalence of neoplastic disease was consistently low at towns in Roman Britain. Both York and Derby are shown in Figure 4.37 as being extreme outliers for osteochondroma. These anomalously high results may be related to environmental or dietary factors associated with the sites (Roberts and Cox, 2003: 113), or may appear elevated because of the rarity of the condition in the archaeological record. Elevated rates may be compounded at Derby by the presence of two examples of a rare condition within a small sample.

4.3.8. Other Pathological Conditions

This section includes evidence of Paget's disease, lytic abnormalities, and abscess/bone cysts.

4.3.8.1. Paget's Disease

Paget's disease is characterised by excessive resorption, remodelling and formation of new bone, resulting in abnormal bone structure (Aufderheide and Rodríguez-Martin, 1998: 413; Mays, 2010: 1839). The exact cause of Paget's disease is unknown, although current research suggests a slowly developing viral condition prone to affecting genetically susceptible individuals (Singer and Mills, 1983; Daroszewska and Ralston, 2005; Mays, 2010).

Only one individual from York may have exhibited osteological evidence of Paget's disease; thickening and porosity of the right clavicle was observed in a 40-60 year old possible female from the York Railway Station site. Very slight thickening and porosity was also observed in the left clavicle, but to a much lesser extent. Paget's disease can manifest in the clavicles, although it is more commonly found in the pelvis, femora and skull (Aufderheide and Rodríguez-Martin, 1998: 414). Unfortunately the remains were also severely abraded, meaning that only a tentative diagnosis could be made.

Table 4.83 shows TPR of Paget's disease in the York assemblage. All other skeletal elements had a TPR of 0%.

Element	Total Elements	Total No. Affected	L	R	L TPR%	R TPR%	Total TPR%
Clavicle	478	2	1	1	0.41	0.43	0.42

Table 4.82: TPR of Paget's disease per affected skeletal element

Table 4.83 shows CPR of Paget's disease in the York assemblage and comparative populations. No data was available for Roman Britain. Data for York includes possible cases. The results show that examples of Paget's disease were only found at two sites. A Fisher's Exact test was performed to examine prevalence of Paget's disease across all observed populations. No significant difference was found between populations or from expected values. These results indicate that prevalence of Paget's disease in the observed sites was consistently low.

	Total No. Individuals	Total Affected	M	F	M CPR%	F CPR%	Total CPR%	Reference
York	785	1	0	1	0.00	0.64	0.13	This study
Ancaster	327	0					0.00	Cox, 1989
Cirencester	424	0					0.00	McWhirr *et al.*, 1982
Colchester	733	0					0.00	Crummy *et al.*, 1993
Derby	112	0					0.00	Wheeler, 1985
Dorchester	1511	6	5	1	1.14	0.22	0.40	Farwell and Molleson, 1993: 196; Davies *et al.*, 2002; Egging Dinwiddy, 2009
Dunstable	112	0					0.00	Matthews, 1981
Gloucester	166	0					0.00	Simmonds *et al.*, 2008
London	183	0					0.00	MOLA Centre for Human Bioarchaeology, 2009a; MOLA Centre for Human Bioarchaeology, 2009b
Winchester	783	0					0.00	Booth *et al.*, 2010

Table 4.83: CPR of Paget's disease at York and comparative towns

4.3.8.2. Lytic Abnormalities

Lytic abnormalities are lesions that form as a result of abnormal bone formation and destruction (Ortner, 2008: 193). Clinically they are often associated with the development of cancer (both benign and malignant tumours), but they can also form in relation to other conditions such as gout and treponemal (Mays, 2008: 83; Ortner, 2008: 193) disease. Eleven individuals from York were observed with a total of 16 lytic abnormalities. CPR was therefore calculated at 1.4%. Absence of further evidence meant that diagnosis of specific conditions associated with the lytic lesions was not possible.

Table 4.84 shows TPR of lytic abnormalities in the York assemblage. All other skeletal elements had a TPR of 0%.

Element	Total Elements	Total No. Affected	L	R	U	L TPR%	R TPR%	Total TPR%
Frontal	296.5	2						0.67
Mandible	289	1						0.35
Cervical Vertebrae	892	1						0.11
Radius	599	1	0	1		0.00	0.35	0.17
Carpals	830	2	0	1	1	0.00	0.23	0.24
Tibia	592	1	0	1		0.00	0.36	0.17
Fibula	494	1	1	0		0.44	0.00	0.20
Tarsals	1186	6	2	4		0.34	0.66	0.51
Metatarsals	978	1	0	1		0.00	0.21	0.10

Table 4.84: TPR of lytic abnormalities per affected skeletal element

While highest prevalence of lytic abnormalities in the York assemblage is in the frontal bone and tarsals, overall prevalence is consistently very low with all values at <1% prevalence. Nine of the affected individuals were from excavations at Driffield Terrace; the remaining two were from the Railway Station and Trentholme Drive, respectively. Ten individuals were male, and one was female; chi-square testing showed that there was no significant difference in prevalence between males and females. Unfortunately, no data was found from comparative populations regarding prevalence or frequency of miscellaneous lytic abnormalities. It could be inferred from these results that prevalence of these types of lesions at comparative sites would similarly be extremely low.

4.3.8.3. Abscess/Bone Cysts

Three individuals from York had lesions indicative of abscess or bone cysts. Data for all three individuals were collated from grey literature, and these specimens were not available for observation by this author (Stroud, 1990; MAP Archaeological Consultancy, 1998; McIntyre and Holst, 2006). Two individuals had a single abscess/cyst. The third individual was described as having several cysts. Table 4.85 shows TPR of abscess/cysts according to skeletal element. All skeletal elements not included in Table 4.85 have a TPR of 0%.

Element	**Total Elements**	**Total No. Affected**	**L**	**R**	**L TPR%**	**R TPR%**	**Total TPR%**
Radius	599	>1	>1	0	0.33	0.00	0.17
Ilium	384	1	0	1	0.53	0.00	0.26
Metatarsals	978	1	1	0	0.21	0.00	0.10

Table 4.85: TPR of abscess/bone cyst per affected skeletal element

TPR of abscess/bone cyst in the York assemblage is very low. The cysts located in the radius are likely to be associated with a healed fracture, and the abscess/cyst in the ilium may be associated with gastro-intestinal tuberculosis. Lack of further evidence related to the example in the first metatarsal means that it is impossible to determine whether this lesion is an abscess or a cyst. Aneurysmal bone cysts do commonly occur in bones of the hands and feet, and their growth may be triggered by an underlying disorder such as trauma or neoplasms such as chondroblastoma or osteoblastoma (Aufderheide and Rodríguez-Martin, 1998: 390). However in this case, any possible underlying conditions, especially those that only affect the soft tissues, obviously cannot be observed.

Table 4.86 shows CPR of abscess/bone cysts in the York assemblage and comparative populations. No data were available for Roman Britain. The results show that CPR of abscess/bone cysts at York and in the comparative populations is very low. Data were not available for most comparative populations. A Fisher's Exact test was performed to examine prevalence of abscess/cysts across all observed populations. No significant difference was found between populations or from expected values. These results indicate that prevalence of abscess/cysts in the observed populations was consistently low. Additionally, no significant difference was found in prevalence of abscess/cysts according to sex.

	Total No. Individuals	Total Affected	M	F	M CPR%	F CPR%	Total CPR%	Reference
York	785	3	1	2	0.34	1.28	0.38	This study
Ancaster	327	5	4	1	3.10	1.20	1.53	Cox, 1989: 61-2
Dorchester	1511	>6	>4	2	>0.91	0.43	>0.40	Farwell and Molleson, 1993; Davies *et al.*, 2002; Egging Dinwiddy, 2009: 65-8
London	183	0	0	0	0.00	0.00	0.00	MOLA Centre for Human Bioarchaeology, 2009a; MOLA Centre for Human Bioarchaeology, 2009b

Table 4.86: CPR of abscess/bone cysts at York and comparative towns

4.3.8.4. Summary: Other Pathological Conditions

To summarise, Figure 4.38 shows the prevalence distribution of Paget’s Disease and abscess/bone cysts across all observed populations. This suggests that prevalence of these conditions was consistently low at towns in Roman Britain. York falls well within these low ranges for both conditions.

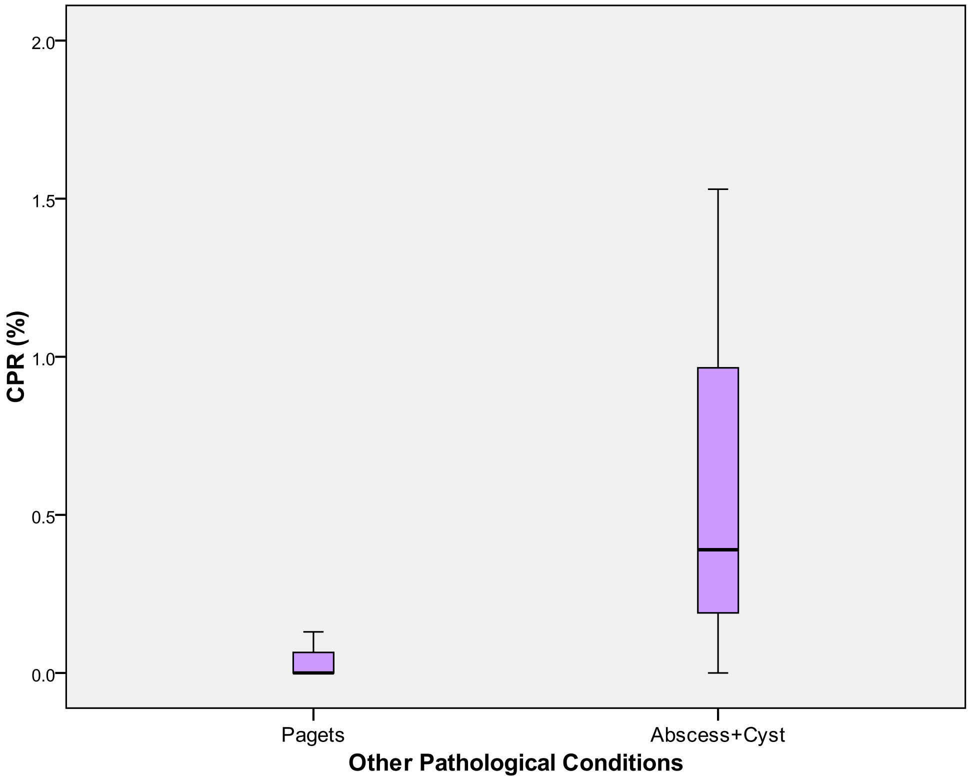

Figure 4.38: Crude distribution of miscellaneous pathological conditions across all towns.

4.3.9. Summary: Overall Patterns of Health in Roman Britain

To summarise this section, Figure 4.39 shows the prevalence distribution of all observed pathological conditions across all observed populations. Outlying values are not included; this Figure shows the observed "normal" distribution ranges.

Across all observed populations, the largest pathological prevalence ranges are for spinal and extra-spinal degenerative joint disease and Schmorl's nodes, suggesting that prevalence of these conditions is highly variable across Romano-British urban sites. These pathological conditions (particularly spinal joint disease) also have the potential for the highest prevalence. Post-cranial trauma, osteochondritis dissecans, non-specific infection, and cribra orbitalia have moderate prevalence ranges at a slightly lower level (up to approximately 15% CPR), suggesting that these conditions are likely to be present in Romano-British urban populations, but with lesser frequency than the degenerative conditions. Decapitation is also moderately prevalent. All other observed pathological conditions have consistently low and narrow prevalence ranges (0-5% CPR) indicating that no more than a handful of examples of these are likely to be found in Romano-British urban populations.

Compared to other observed Romano-British populations, York had significantly elevated prevalence of craniofacial trauma, and porotic hyperostosis. All other pathological conditions were within the ranges shown in Figure 4.39. Prevalence of peri-mortem trauma, dislocation, os acromiale, brucellosis, osteopenia and osteochondroma was comparatively high at York, in the higher end of the calculated prevalence range for each condition. All these results will be discussed further in Chapter 5.

The findings of this study are general, broad, and largely apply to the population during the later period of occupation of *Eboracum*. Overall, results indicate that in terms of stature, males from *Eboracum* are taller than expected, while females are slightly taller than their counterparts from comparative urban sites but still within the expected height range for Roman Britain as a whole. The town's populace has a significant male bias, life expectancy at birth is slightly higher than expected, and adult male and female life expectancies are approximately equal. There appear to be three cemetery areas in use around *Eboracum,* with the most preferential cemetery located on the south west road. The overall population size is likely to have been bigger than previous estimates have proposed, with around 12-14,500 individuals inhabiting the town. Diets are likely to have had significant fat and protein components, with lesser inclusions of cariogenic foods and foods containing vitamins and calcium. In terms of health, the population exhibits high rates of pathological conditions such as trauma. The next chapter will discuss these findings in relation to other archaeological and contextual evidence relating to *Eboracum,* Roman Britain and the wider Roman Empire.

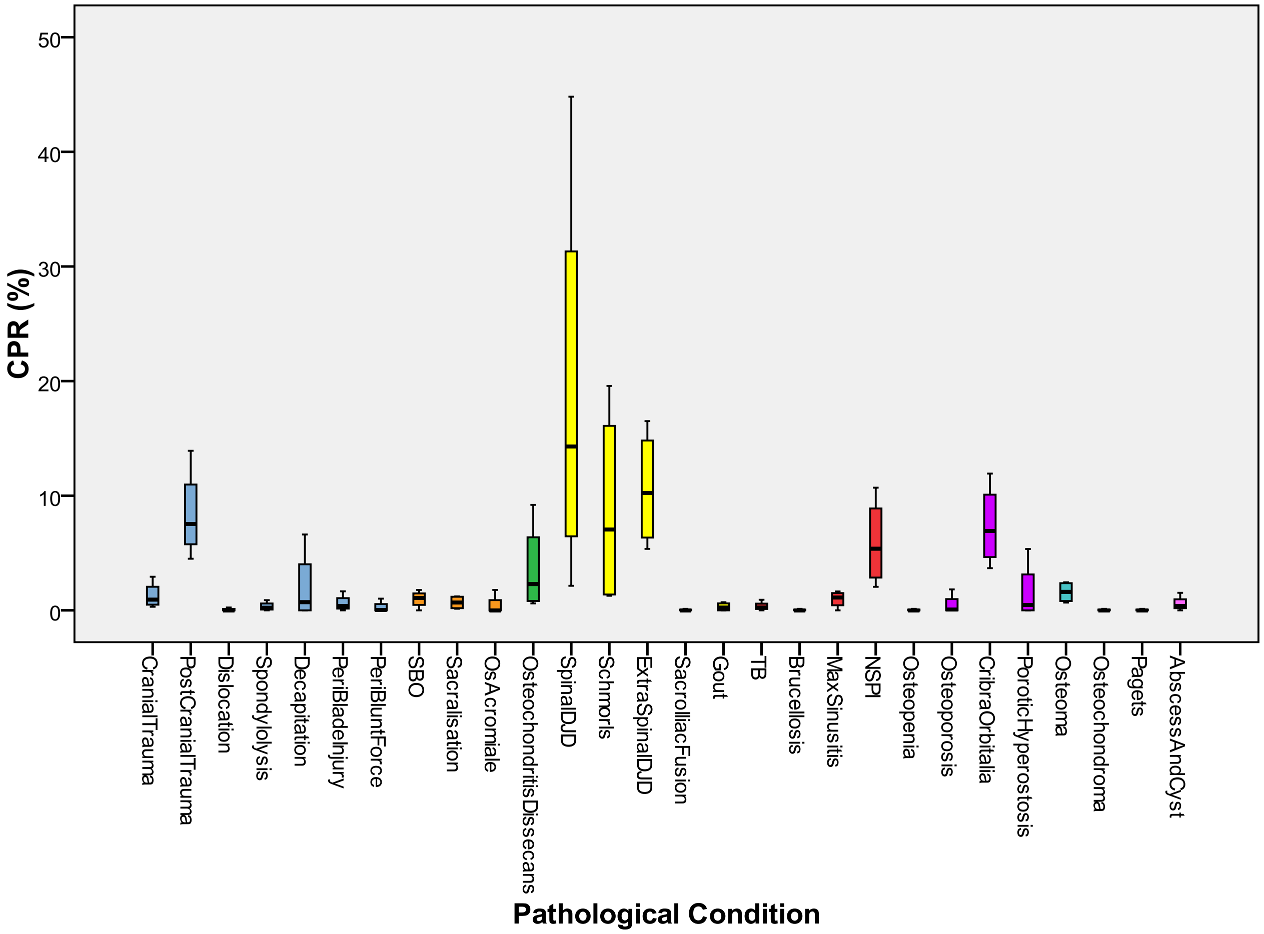

Figure 4.39: Crude distribution of all pathological conditions across all towns. Blue = trauma, orange = congenital, green = circulatory, yellow = joint disease, red = infectious disease, purple = metabolic/deficiency, turquoise = neoplastic and pink = miscellaneous condition

Chapter 5: Discussion

The key findings of this study are fivefold. Firstly, the population of *Eboracum* is likely to have been bigger than previously thought. Secondly, the demographic composition of the population is moderately affected by the presence of the military. Thirdly, this study confirms the theory that the preferential burial area was located on the southwest road heading out of *Eboracum* (RCHME, 1962: 76-80; Ottaway, 2004: 12 and 122). Fourthly, the osteological evidence suggests that diet contained higher than expected proportions of food containing fat, protein and non-fermentable carbohydrates, and lower than expected proportions of food containing sugar, sucrose, starch and fermentable carbohydrates. Finally, although the prevalence of many pathological conditions fell within the expected range for Romano-British urban settlements, there were significantly higher than expected rates of several conditions, particularly trauma.

This chapter will synthesise the findings of this study and explore their significance in light of known archaeological evidence from *Eboracum* (as outlined in Chapter 2). The first section will address the results of the demographic study and what implications this has for our understanding of the size and composition of the population of *Eboracum*, as well as briefly discussing reasons for the location of preferential cemetery areas. The second section will combine this study's osteological evidence for diet with dietary evidence from previous studies in order to establish an overall dietary pattern for the population of *Eboracum*. The third section will draw together this study's osteological evidence for health status to create a broad health profile for the population, and suggest explanations concerning why the population has significantly higher rates of certain pathological conditions.

5.1. Demography: Population Size and Composition

The results of this analysis suggest that it is likely that *Eboracum* had a population numbering between 10,000-14,500 individuals at any one point in the 339 year period covered by this study. It should be noted at this point that the methods and materials used to make these estimates mean that the calculated population size range is probably more applicable to the mid/later period of occupation (approximately c.150-350; the town may have begun to experience decline/depopulation when the occupying legion was removed in the late fourth century). The dearth of (typically earlier) cremation burials available for study means that the majority of burial data used in the calculations pertains to the mid/later part of the period of Roman occupation, from c.150-350 A. D. Similarly, the method of population size estimation based on the size of the settlement area utilised spatial data from all three areas of the town (fortress, *canabae* and *colonia*), which would have only been fully developed from the late second/early third century. Tighter estimations for the earlier population may be possible in the future should more accurate dates be ascribed to a larger proportion of burials. Comprehensive dating and tighter phasing of the archaeological settlement data would give a better picture of the extent of the settlement and its growth over time. This would allow for estimation of the population size over smaller, more specific periods of time, facilitating observation of population growth and change throughout the period.

The calculated population size estimation presented in this study suggests that *Eboracum* is more comparable in terms of size to populations from Romano-British urban sites such as London (approx. 10,000 individuals), Colchester, St. Albans and Cirencester (approximately 15,000 individuals, assuming these estimates are correct), even though these sites may differ in terms of spatial extent (Potter, 1992: 68; Frere, 1992: 256; Ottaway, 2004: 128). The *Eboracum* estimate, though crude, is bigger than previous estimations of 7,000-10,000, potentially doubling the assumed size of the population. Previous estimations for the size of the military population (5,000-6,000) do fall within this study's "standard" to "maximum" military population size range of 5,240-7,500. A high degree of confidence that these results approximate the actual size of the military population is gained as a result of similarities in these estimations. The bigger population estimate produced by this study may, therefore, be the result of an enlarged civilian population.

As previously stated in Chapter 2, *Eboracum* was founded by the Roman Army in the first century A. D. There is no evidence of formal, nucleated settlement at this location prior to this, and it is generally accepted that the indigenous populations of the area inhabited widely scattered farmsteads and small villages (Ottaway, 2004: 26-9). Therefore, all the original inhabitants of *Eboracum* would have to be migrants of one sort or another, whether serving in or associated with the army, or coming from the wider rural area around the new settlement. Establishment of a formal settlement, especially one that would later develop into the capital of the province, would naturally attract migrants from places as close as local rural areas and as far afield as other regions of the wider Roman Empire. The first major settlement in a region would probably attract people from both the immediate vicinity and further afield by economic and social opportunities such as trade, jobs, money and status (the "pull" of the city; De la Bédoyère, 2003: 15-8; Jongman, 2006: 108). Similar inward migration has been noted at Winchester, where the town's *civitas* status coupled with economic factors associated with the presence of an Imperial weaving works have been cited as probable draws that would have attracted migrants (Eckardt *et al.*, 2009: 2823).

As well as the local migrants, there would have been the founding army itself and a "baggage train" of associated individuals: wives, families, servants, slaves, concubines, prostitutes, soothsayers and traders are just some of the accompanying individuals mentioned in a variety of Roman epigraphic and primary literary sources (Allason-Jones, 1999a; Hassall, 1999; Prowse *et al.*, 2007: 512; Eckardt *et al.*, 2009: 2823; Allison, 2011: 161-4; 171; 177). Slaves, in particular, are cited as making up a large proportion of Roman urban populations (Jongman, 2006: 116; Prowse *et al.*, 2007: 512). As discussed in Chapter 2, there is evidence from *Eboracum* that a significant proportion of the population was also made up by veteran soldiers who continued to reside in the settlement after retiring from the army (Brinklow, 1984: 22). All these factors would contribute to an increase in population size as well as increasing the urban growth rate. The resulting population increase then impacts on reproductive capacity, further boosting the size of the population. With high potential for migrants, numerous dependants and followers, it is easy to see how the population of *Eboracum* could swell to the size postulated in this study.

The population size estimates produced in this study are only crude. The methods utilised assume that the population is static, not taking into account potentially differential fertility or mortality rates, migration in or out of the settlement and so on. Clearly the military population would not be static, especially during the later occupation of *Eboracum* by the Sixth Legion: archaeological evidence for level of occupation in the fortress appears to decrease during this time, and Ottaway (1999: 141) suggests that this may be because the Sixth Legion was also spending time at Hadrian’s Wall and the Antonine Wall. Frier (2001: 141-2) also suggests that populations in western parts of the Roman Empire would be unlikely to reach their theoretical maximums (for example in Britain, because the pre-Roman population was relatively small), although it is unclear whether this statement refers to individual settlements or the wider region. While these factors and the inherent palaeodemographic methodological problems discussed in Chapter 3 may render such population size estimations as no more than educated guesses, it is the view of the author that an educated guess is better than no guess at all. Furthermore, the production of an estimated population range (based on the results of multiple palaeodemographic methods) rather than a single figure may account for population fluctuations that cannot otherwise be compensated for.

The results of this study clearly demonstrate that the military presence at *Eboracum* is reflected in the population’s demographic profile. Males are slightly taller than average for the period, although this is not statistically significant. Roth (1999: 9) has postulated that passages in writings by Tacitus and Apuleius suggest that Roman soldiers were taller than the average male civilian. Vegetius’ *Epitoma rei Militaris*, written in the late 4th century, states that the minimum height requirement for soldiers was 5 feet 10 inches (although this refers to the Roman measurement, the modern equivalent being 5 feet 7 1/2 inches, or 172cm; Davies, 1989: 4; Milner, 1996: 6). The *Eboracum* average male stature of approximately 171cm falls slightly short of this given minimum requirement; however minimum height requirements for the army are likely to have differed according to rank, and it is also unclear whether these requirements would have applied to the entire military population, or, indeed, been adhered to (Roth, 1999: 9-10). Furthermore, Vegetius’ writing dates to the fourth century A. D., and the time period that these regulations were supposedly in use is unclear (Milner, 1996).

Perhaps more significant is the clear male bias in the population's sex ratio. The difference in proposed proportion of males at Trentholme Drive between the original 1968 study (3.74: 1 males to females: Wenham, 1968: 147) and the reappraisal in 2009 (1.79: 1 males to females: Peck, 2009) is highly likely to be the result of changes in standard osteological methodology since the Trentholme Drive study took place in the 1950's and 1960's. The overall sex ratio calculated for Roman York in the present study stands at 1.88: 1 (males to females), and is far closer to Peck's (2009) more recent estimation. The sex ratio calculated in the present study is still significantly biased towards males. As well as the presence of the army/veterans, genuine excess numbers of males (or a deficit in the number of females, as the sex ratio proposed in this study may reflect either scenario) within a Romano-British population may also be explained by a combination of any of the following factors: selective female infanticide; migration; cultural separation of males and females within the cemetery; preservation bias; sample size and methodology. This next section will assess the extent to which each of these factors is likely to have contributed to the sex ratio observed in this study.

Evidence presented in Chapter 2 has already demonstrated that *Eboracum* had a large military presence. Given the population size estimates proposed in this study (see Chapter 4: pages 149-158), the military may have accounted for up to half of the overall population of *Eboracum*. Even if a certain proportion of these individuals were female (as discussed by Allason-Jones, 1999a and Allison, 2011), the majority would undoubtedly be male. Even if the remaining civilian populace had a sex ratio approximating the expected 1: 1 males to females, the presence of the army (whether at its minimum or maximum possible size) would have an enormous bearing on the sex ratio of the town (Davison, 2000: 233). Furthermore, the potential of retired army veterans remaining in *Eboracum* once they had finished active service means it is unsurprising that significant male bias was observed within this population.

Selective female infanticide (usually thought to have been practised in parts of the Roman Empire when female children were viewed as less desirable than male children) is often quoted as a possible reason for male bias within a population, often with little other explanation or reasoning for this (e.g. Cox, 1989: 7; also Mays, 1995 postulates female infanticide may be responsible for sex bias at Cirencester, Colchester Butt Road, Winchester Lankhills and Trentholme Drive in York). However, despite literary and epigraphic references to infanticide and exposure (e.g. in Oxyrhynchus papyrus 744, dating to the first century B. C.; Grenfall and Hunt, 1898: 243; Hope, 2007: 14), the extent to which infanticide was actually practised has been debated (Engels, 1980; Harris, 1982; 1994; Bagnall and Frier, 1994: 149-51; Davison, 2000: 233; Mattingly, 2007: 479). Furthermore, infanticide, particularly sex selective infanticide, is difficult to demonstrate archaeologically.

The evidence for infanticide in Roman Britain is somewhat speculative. Mays (1993; 2000; 2003) in particular has argued that infanticide was regularly practiced in Roman Britain. However, in many cases it could be argued that concentrations of infant burials, unusual treatment or unusual location of infant burials are simply reflective of the diversity of funerary practices utilised for this social group (Philpott, 1991: ch. 18; Mattingly, 2007: 479; Carroll, 2011; Rogers, 2011: 147; Carroll, 2012). Alternative explanations for infant death can also include stillbirth and death due to disease (Waldron *et al.*, 1999: 77-8). Osteoarchaeological studies of infanticide often concentrate on assemblages with a large proportion of infant burials, using a combination of demographic profiling and available archaeological evidence to ascertain whether the observed mortality pattern should be considered as “natural” or not (e.g. Smith and Kahila, 1992; Tocheri *et al.*, 2005; Halcrow *et al.*, 2008; Mays and Eyers, 2011). Yet, these studies are not without criticism: it has been suggested that the results of such demographic profiling may be subject to inherent methodological bias, and may simply end up reflecting the demographic structure of the reference population used to create the methodology (Gowland and Chamberlain, 2002; Chamberlain, 2006: 172). This issue is still up for debate.

Even in cases where the majority of evidence does indicate that a burial assemblage may be the result of infanticide, the individual skeletons are not necessarily (or cannot be) tested to establish biological sex. For example, Mays and Eyers’ (2011) study concluded that a group of 33 perinatal burials from a

Roman villa site at Hambledon in Buckinghamshire were the victims of infanticide: no further work has been conducted to try to establish whether the group has a sex bias. Similar studies that have tested for biological sex (for example using ancient DNA) have generally been too poorly preserved or had too small a sample size to glean any meaningful results, and no evidence of significant sex bias has been found amongst these samples (Waldron *et al.*, 1999; Mays and Faerman, 2001).

It should also be noted that infanticide is not an act that is necessarily characterised by the involvement of large groups of children. A smaller quantity of individuals (or a single individual) is less likely to be characterised as being a victim of infanticide unless an unnatural cause of death can be ascertained osteologically and contextually. It is therefore apparent that investigation of infanticide in the past is extremely difficult, and very little conclusive evidence for the occurrence of this practice in Roman Britain has been found (Davison, 2000: 235). Thus, while infanticide (sex selective or not) in *Eboracum* cannot wholly be ruled out, the current lack of evidence suggests the practice is unlikely to have contributed in any significant way to the male sex bias observed in this study.

Migration must also be taken into consideration when examining the demographic structure of a population, as along with birth and death rate, it plays a key defining role (Anthony, 1990: 897). In fact, migration has the potential to play such a major role in ascertaining the composition of a population that it may totally undermine any attempt to reconstruct a population using cemetery data (Scheidel, 2001: 46). This is largely due to the fact that many of the variables associated with migration are unknown or unquantifiable, are unlikely to be constant, and therefore are very difficult to measure or compensate for (Scheidel, 2001: 46-7). In this study, the population has been considered as static, which is also problematic if trying to measure the effects of migration. For these reasons, migration is only discussed here in very broad, generalised terms.

Stable isotope studies, from both *Eboracum* and other Romano-British towns, have attested to the presence of immigrants, either from other areas of Britain or further afield. It is highly likely that these individuals (particularly those from further away) came to these towns because of connections with the army or the attraction of urbanisation. For example, evidence for migration from elsewhere in Britain was found at Catterick, which may be indicative of a change to more local army recruitment in the later Roman period (Chenery *et al.*, 2011). As discussed in Chapter 2 (pages 41-3) and elsewhere in this chapter, evidence of immigrants (and probable second generation immigrants) from the Mediterranean and North Africa has been found in *Eboracum* (Leach *et al.*, 2009; 2010; Müldner *et al.*, 2011). Similar evidence has been found at other urban sites in Britain: a small proportion of individuals from the Lankhills cemetery in Winchester have been found to hail from the Hungarian Basin and the southern Mediterranean (Evans *et al.*, 2006; Eckhardt *et al.*, 2009); non-British individuals were also found in the London Road cemetery in Gloucester (Chenery *et al.*, 2010). Whether coming from more local areas or the opposite side of the Empire, it is clear that Romano-British towns have the potential to be highly diverse.

When referring to the situation at *Eboracum*, it should be noted that in the earlier period, migration refers more specifically to the civilian population. Prior to establishment of the site by the Ninth Legion there was no formal settlement in this location: while the army could be perceived as migrants, they should in fact be viewed as colonists, as the initial recipient population has a value of zero, because migration is taking place into an unoccupied region (Chamberlain, 2006: 40). The people attracted to the settlement as a result of the army's presence are the true migrants referred to here.

Although the grounds for migration are likely to be extremely complex, commonly cited causes include (but are not limited to) perceived increase in employment opportunity, the desire to escape/avoid hazards (e.g. disease, conflict), improved living conditions, marriage, and proximity to other members of the family group (Connell *et al.*, 1976; Brummell, 1979; Wiseman and Roseman, 1979: 330-1; Anthony, 1990: 898-901; Chamberlain, 2006: 39). Furthermore, migration is likely to involve a certain degree of fluidity between the donor and recipient populations, with both populations interacting and individuals or groups probably moving backwards and forwards between the two. Migrants may belong to certain demographic groups, and hence have the potential to affect the structure of a recipient population. General trends suggest that migratory groups tend to fall within certain age cohorts, with migrants typically being young adults (possibly with associated dependent offspring) or elderly adults moving around the time of retirement from employment (Rogers, 1988; Chamberlain, 2006: 39).

Sex bias may be noted in some of these migratory populations. For example, a number of studies suggest that expanding farming communities tend initially to send out young males as “scouts”, with the age and sex structure of the “scouting” population therefore being heavily biased towards this demographic (Simkins and Wernstedt, 1971; Lefferts, 1977; Anthony, 1990: 905). As time progresses, the age and sex structure of the population broadens as more people follow the “scouting” group (Lefferts, 1977: 40; Anthony, 1990: 905). However, this type of “scouting” migration and related male bias does not seem to be a general trend. Therefore, it is suggested that migration is more likely to have an impact on the age structure of the recipient population than the sex structure. Sex structure may be affected substantially in some cases, but in most cases bias is likely to be minimal. This idea has been confirmed by recent isotopic studies. For example at the town of Portus near Rome, migrants were a combination of young adults and children, interpreted as both independent adults and young families (Prowse *et al.*, 2007). Therefore, while migrants may have had some influence on the sex structure of the population of *Eboracum*, the contribution towards a male sex bias is likely to be minimal.

Sex bias within a cemetery population may also be influenced by cultural separation of males and females within a cemetery, although there have been few attempts to address or explore this possibility in Roman Britain (Davison, 2000; Watts, 2001: 337). Occasional clusters of single sex burials have been excavated at a number of sites, e.g. King Harry Lane in St. Albans, Lankhills, and London Road in Gloucester (Clarke, 1979; Millett, 1993: 262; Simmonds *et al.*, 2008), echoing tentative evidence for zoning of burials elsewhere in the Empire, e.g. Vagnari in Puglia (Small *et al.*, 2007: 132). However, these groupings are often relatively small, and tend to be male based. Davison (2000: 234-5) suggests that as no complete Roman-British cemeteries have been excavated, it is possible that female dominated groupings lie in “less visible” cemetery areas that have not yet been picked up archaeologically. While this may be true at many sites, the wider area surrounding *Eboracum* has been quite extensively excavated, and has yielded little evidence for specifically female groupings. However, Davison (2000) also fails to address one very important question: if females were being selectively buried in “less visible” areas, why are there so many female burials found co-mingled with males in the majority of excavated Romano-British cemeteries? Furthermore, sex based imbalance in Romano-British cemeteries is almost exclusively an urban phenomenon, which Davison (2000: 235) explains as differential burial tradition linked with urbanisation. It is the view of the present author that the presence of sex bias at urban cemeteries is more likely to be a reflection of genuine sex bias within urban populations, for some of the reasons discussed earlier in this section. More equal sex distribution at rural sites during the Roman period is probably due to the absence of additional military presence.

Other theories suggest that any observed cemetery grouping of males and females in Roman Britain may be accidental, or at least an accidental by-product of selective burial location for other reasons. Philpott (1991: 233) suggests that there is very little difference between the treatment of men and women in terms of burial practice at this time. Burial location is most likely to be chosen or affected by cultural, religious and social factors, e.g. wealth/status, age, ethnicity and religious beliefs (Chapman, 1980: 59; Philpott, 1991: 228-41). Therefore, individuals may be buried in a certain location because of membership of a distinct group within the living community, e.g. burial clubs, families (Simmonds *et al.*, 2008: 141). If these groups have a sex imbalance, this, in turn, will be reflected within the burial cluster and may be incorrectly perceived by archaeologists as a grouping made according to sex (Roberts, 1985: 461; Simmonds *et al*., 2008: 141). This may explain the extreme concentration of male burials at Driffield Terrace in *Eboracum*, where females were completely absent.

Overall, evidence for deliberate grouping according to sex in Romano-British cemeteries is unconvincing. Zoning of male burials (with total absence of females) was only observed at sites along Driffield Terrace; statistical analysis in

Chapter 4 demonstrates that absence of females at these sites does not skew the data, as male bias is observed almost across the board. Male bias observed in the York assemblage is unlikely to be significantly affected by the deliberate cultural separation of male and female burials, instead being an accidental by-product of group membership within the community.

Differential preservation of male and female skeletons is sometimes cited as a cause of male bias in archaeological populations. However, there is little in the way of experimental proof that female bones degrade faster than those of males. A study of individuals dating from the seventeenth to nineteenth centuries from St. Bride's Church in London, found significant bias in the preservation of pubic bones (with male bones more likely to be preserved), although it is unclear how much these preservation levels could be due to other factors such as age and burial environment (Walker, 1995). Furthermore, it is inappropriate to use this finding as evidence for male/female preservation rates in other skeletal elements. A study of preservation bias by Bello *et al.* (2006) found some evidence of preservation bias (in favour of males) in skeletal samples, but only in infants. Tentative evidence therefore suggests that bone degeneration that leads to preservation bias in a skeletal sample is much more likely to be related to age than sex (Walker *et al.*, 1988: 187; Bello *et al.*, 2006).

Other commonly cited reasons for sex bias within an archaeological skeletal sample are related to methodological or sampling flaws. It has been recognised that many older osteological reports contain extreme male bias, which may be reflective of inaccuracy in past osteological sexing techniques (Davison, 2000: 234). Extreme sex ratios such as the one discussed in the original Trentholme Drive report are often the product of methods that could now be considered out of date, though the results themselves are still frequently quoted (Wenham, 1968; Davison, 2000: 234). The comprehensive re-assessment of the Trentholme Drive assemblage by Peck (2009) has demonstrated that the original sex ratio proposed by Warwick (in Wenham, 1968) is grossly inaccurate. Older assemblages may therefore require re-assessment in light of newer, standardised osteological methods, lest perceived acute biases continue to influence our understanding of populations.

However, even modern osteological sexing methods are not without flaws. Current sexing techniques often rely on macroscopic identification and assessment of sexually dimorphic characteristics of the skull and pelvis, based on size and robusticity (Weiss, 1972: 97; Chamberlain, 2006: 90-1). Osteologists are more likely to classify traits with an intermediate (i.e. neither robust nor gracile) appearance as male, and the likelihood of classification as male increases in skeletal remains with an age at death older than 30 years (Weiss, 1972: 97; Chamberlain, 2006: 90-1). This, combined with potential age related changes in cranial morphology (Walker, 1995: 39-40; suggests that some aspects of female cranial morphology may become more robust with increased age) may therefore lead to misidentification by the osteologist and subsequently suggest male bias within the assemblage. Weiss (1972: 243) proposes that approximately 10-15% of an assemblage may be misidentified for these reasons. Therefore, inherent methodological problems may account for some of the male bias identified in this study, but are unlikely to be wholly responsible.

The reliability of the observed sex ratio also depends on how representative the sample used in this study is of the living population. This reliability is at least partly related to excavation strategy. If the excavated sample is unrepresentative, the observed sex ratio may not accurately reflect the sex ratio of the living population. In this case the sample comprises all skeletal material (or skeletal data) that was available for study. Material from all sides of York was utilised, covering the full period of Roman occupation of the town. As demonstrated in previous chapters, the overall sample was also of a substantial size.

Results presented in Chapter 4 demonstrated that significant male bias was found at three out of the five largest discrete cemetery assemblages used in this study (1-3 Driffield Terrace, 6 Driffield Terrace and Trentholme Drive). Sites with single or smaller groups of burials (less than 20), when collated together, also exhibited significant male bias. Taking into consideration the total sample size and wide range of burial locations covered by this study, these findings suggest that the male bias observed here is genuine, and not the result of sample bias. Sample bias appears to be present within some discrete cemetery assemblages (Lion and Lamb

Car Park and York Railway sites had approximately equal distributions of male and female burials, and are therefore unrepresentative samples of a genuinely biased population). This has a minimal effect on the overall sample.

To summarise, the population of *Eboracum* appears to be genuinely significantly biased towards male individuals. The evidence suggests that the main reason for this is the considerable military presence at the town, which would have comprised both active soldiers and retired veterans. Migration of young males to *Eboracum* from both the local and wider area may also have contributed to this bias, although not as significantly. Inherent bias within standard osteological sexing methods may also be a lesser contributor. Sample bias is likely to be minimal. Other commonly cited reasons for a deficit in the number of female individuals such as selective female infanticide, cultural separation of male and female burials and differential male and female preservation rates are unlikely to have contributed towards the observed bias.

Analysis of mortality profiles in this study allows broad conclusions to be drawn about the age structure of the living population. The results presented in Chapter 4 show that the *dx* curves representing proportional mortality according to age constructed for Roman York reflect under-representation of infants, slight over-representation of late adolescents/young adults and gross over-representation of mid/older adults. Absence of infants, what should be a rather large percentage of the population, causes subsequent proportional over-representation in all later age categories. This may partially explain the higher proportion of adolescents present in *Eboracum*. Methodological bias (potential over or under aging in some adult age categories) and clustering around mean ages, something which is particularly evident in the mid/older adults, also exacerbate these problems. This demonstrates why considerable caution should be exercised in drawing conclusions from curves constructed using raw osteological data.

The results of this study suggest that the sub-adult population of *Eboracum* requires more investigation. Data for only 75 sub-adults (individuals aged 0-14 years at death) were available for this study, which comprised 10.7% of the aged skeletal sample (9.6% of the total skeletal sample). It has already been stated that taphonomy (e.g. bioturbation), socio-cultural factors (e.g. differential burial of infants) and sampling bias/error are likely reasons for under-representation of the very young. Unfortunately it is impossible to tell, based on current information, whether observed proportions of sub-adult/adolescent remains reflects genuine mortality or slight over-representation as a result of the dearth in the number of infants. Additionally, there is the possibility that reproduction rates in the town were reduced, with the population being continually replenished by adult migrants and children born elsewhere. The addition of data from 30 infant and sub-adult burials discovered recently at Hungate (Connelly, pers. comm.) may facilitate more in depth palaeodemographic study of the sub-adult population of *Eboracum*, as well as investigation into possible zoning of sub-adult burials.

Application of the Bayesian “smoothing” affords some compensation for the inherent biases in the adult data. Naturally, this method is not capable of completely eradicating bias from the results. However, it does at least limit the effects of bias from osteological aging methods, particularly in individuals aged between 25 and 45 years at death (Gowland and Chamberlain, 2005: 152; Gowland, 2007: 158). Often, archaeological assemblages produce a mortality peak at around 35 years of age; the application of Bayesian “smoothing” has been shown to effectively remove this (Gowland, 2007: 158). The smoothed adult curves presented in Chapter 4 (Figures 4.11-4.13 page 134-5 and 137) still exhibit a slight mortality peak in the 25-34 year category. This was observed in both males and females, though was more prominent in the male distribution. The presence of this slight peak, even after data smoothing, indicates that this may reflect a genuine mortality peak in the living population (Gowland, 2007: 159; Chamberlain, pers. comm.).

So, how might a mortality peak in this age bracket be explained? Unfortunately, any explanation more than broad speculation based on scant evidence requires detailed further study, so the following suggestions are only tentative. Scheidel (1996: 99-102) estimates that the average age of enlistment for legionary soldiers was approximately 20 years of age. Scheidel (1996: 121) also calculated that mortality of the military population could be slightly elevated than that of the civilian population. This study calculated that average adult life expectancy for males in *Eboracum* was approximately 36 years. However, if military mortality is slightly higher than expected, average military adult life expectancy would be slightly lowered. Males serving in the military would therefore be more likely to die between the ages of 20 and 36 than civilian males: this could theoretically cause the slight mortality peak observed in the 25-34 year age bracket. This supposition should be regarded cautiously, especially because the adult life expectancies calculated for this study were based on both military and civilian data. However, the possibility remains that slightly elevated mortality rates within the military population could be responsible for the elevated proportion of deaths in younger/mid adult males.

A female peak (albeit less pronounced) in the 25-34 year age bracket is more difficult to explain: it is suggested here that such a peak may relate to the presence of soldiers' wives. Again, it should be noted that this suggestion is very tentative and requires further investigation. Allison (2011: 162) discusses a passage in Herodian's third century *History of the Roman Empire Since the Death of Marcus Aurelius* (3.8.4-5) where it is stated that Emperor Septimus Severus lifted the ban on marriage for ordinary soldiers, a change in the law that is likely to have occurred around 197 A. D. Textual evidence, for example Titus Livius' first century B. C. work, *The History of Rome* (book 43, chapter 3), suggests that soldiers may have taken wives before this change in the law, but these marriages would not have been considered legal (Allison, 2011: 165-7). This change in the law meant not only that soldiers could legally marry, but also that their wives could travel with them during active service. Epigraphic evidence from *Eboracum* shows that at least some of the higher ranking members of the military population had brought their wives to the town from elsewhere in the Empire (Allason-Jones, 1999a: 41-3). It would be unreasonable to assume that soldiers of lower ranks would not do the same (or marry local inhabitants) if permitted to do so.

As of yet, there is no evidence from *Eboracum* regarding the age that people were likely to marry. However, Bagnall and Frier's (1994: 118) demographic study of census data (largely dating to the second and third century A. D.) from Roman Egypt reported a mean age gap of 7.5 years between husbands and wives. The study suggests that women in this particular population were likely to marry at a younger age, to slightly older men (Bagnall and Frier, 1994: 118). Assuming that newly recruited soldiers would be less likely to marry (perhaps because of practical restrictions/factors concerning training etc) we may infer that soldiers and officers would be likely to serve a number of years in the army before taking a younger wife. Could this have caused the observed mortality peak? Clearly, caution must again be exercised regarding this theory, as available evidence is scant. Even if marriage of soldiers to younger women did cause a slightly disproportionate number of females in the 25-34 year age bracket, it is unknown whether the number would be enough to significantly affect the mortality curves. Furthermore, the population of Roman Egypt was obviously very different from that of *Eboracum*, comprising of a different cultural mix of inhabitants which presumably would have significant bearing on socio-cultural practices such as marriage. Therefore, this idea is only a tentative suggestion, and something that could be considered for future, more in depth investigation.

Alternatively, it is possible that the observed peak is still the result of the methodology. Smoothing was only conducted using data from individuals with an auricular surface and/or pubic symphysis. As many post-cranial elements from individuals in the study were missing or insufficiently preserved to score, this served to reduce considerably the size of the sample used to create a mortality distribution. This again introduces a number of limitations, including the possibility that these reduced samples are now less representative of the parent population. Furthermore, criticism of the Bayesian smoothing method has focussed on the issue of whether this approach is capable of removing inbuilt bias occurring from original reference samples used in establishment of the given aging method (Jackes, 2011: 119). For example, the Suchey-Brookes pubic symphysis aging method was based on a reference sample that was biased towards late adolescents and young adults; the sample utilised remains from late twentieth century urban American forensic cases, and therefore was not representative of an attritional mortality profile (Brooks and Suchey, 1990; Jackes, 2011: 119). While it is beyond the scope of this study to investigate comprehensively whether this is the case here, it should be reiterated that the mortality peak occurring in the York profile occurs in smoothed curves based on both the Lovejoy (*et al.*, 1985) auricular surface and Brooks and Suchey (1990) pubic symphysis methods in the

25-34 year old age category. This observed bias therefore occurs in a slightly later age category than may be expected if bias were the result of the reference sample. Although further investigation of this matter is clearly required, it may tentatively be suggested that the observed mortality peak is unlikely to be the result of reference sample bias.

Life expectancy at birth for the population of *Eboracum* (32.26 years) was within the generally quoted 20-30 year life expectancy range for populations residing in the Roman Empire (Hopkins, 1966: 263; Frier, 2001: 144-5; Scheidel, 2001a: 24; Scheidel, 2001b: 29). Of course, all estimations are approximate. Adult life expectancy was higher, with females having a slightly higher adult life expectancy (37.1 years) than males (36.22 years), which again, is a bit higher than general adult life expectancy for the Roman Empire (35.7 years, males and females combined; Frier, 1982: 247).

This one year discrepancy between male and female adult life expectancy is not significant, meaning that adult life expectancy between the sexes is approximately equal. Where adult life expectancy between sexes is more even, it is possible that this is the result of military presence at these sites. Settlements with a significant military presence are likely to have elevated numbers of younger adult males, which therefore contributes to a younger age at death profile than may be expected in males. This may bring the usually elevated male life expectancy down so that it falls more in line with female rates. It is interesting to note that three of the sites (York, Colchester and Gloucester) exhibiting more even life expectancy rates between males and females have *colonia* status; as previously discussed, London may also have been a *colonia*, though current evidence does not wholly confirm this (Mattingly, 2007: 268 and 274-5).

Having said this, Dorchester, Dunstable and St. Albans have 1-1.5 year life expectancy discrepancies. The remaining comparative sites had higher male life expectancy, with discrepancies ranging from two to eight years. Although male adult life expectancy at these sites was slightly higher, figures are still approximately equal and none of these three sites had notable military residency. Again, factors such as sample size and recovery bias will affect the accuracy of all given estimations. Dunstable and St. Albans had notably smaller sample sizes (n=88 and n=71 sexed individuals respectively), which may therefore have contributed to producing less accurate results (small sample size may also have affected results for Derby, with a two year life expectancy discrepancy and only 48 sexed individuals). The Dorchester sample was substantially larger (n=984 sexed individuals), so sample size is not likely to be an issue. Clearly a more complex series of factors are causal in this case, and only future work will help determine the reason why adult life expectancy in this sample is so equal.

The demographic work conducted in this study shows that the military presence at *Eboracum* had a significant effect on the composition of the town's populace. This finding is unlikely to come as a surprise: even minimal occupation of the fortress by the military is likely to have had a significant impact on the rest of the settlement. While certain elements of military/civilian life would have differed greatly, it is also inappropriate to think of the two populations as completely separate. Initially, this study aimed to consider the military and civilian populations separately. However, it has become apparent during the course of the project that this separation was not strictly necessary. The military and civilian factions of the population are extremely hard to distinguish without the presence of epigraphic evidence (mainly from related tombstones). Apart from some zoning of male burials around the Driffield Terrace area, the military and civilian burials are intermingled. There is also an increasing body of evidence for civilian/family inhabitants in military installations (Allason-Jones, 1999a: 41-51). Both factions, though (mostly) separated spatially (in terms of area of habitation), and partaking in differential occupational roles, would have interacted with each other on a daily basis: trade, politics, administration and personal relationships are just a few facilitators of this interaction. The relationship between the army and civilian inhabitants of *Eboracum* is unlikely to have been completely symbiotic, but it is clear that each part of the population would have had significant influence on the actions and development of the other.

Palaeodemography is a complex and problematic discipline. The palaeodemographic results of this project are largely tentative, broad and general in scope, principally because of the methods and materials available. However, this study is the first real attempt at comprehensive analysis of the structure and composition of the population of *Eboracum*. Although some of the results may not be particularly surprising (for example that the population has significant male bias), this is the first time that there has been systematic analysis to provide demographic evidence on which to base these theories on. More in-depth work of this nature could be conducted: the aim of this project was to get a broad overview. As of yet, there is no perfect palaeodemographic methodology when dealing with osteological data. In the words of P. A. Brunt (1971: 3), “this obstacle does not mean that the attempt is not worth making ... the estimate still be better than nothing”. While it may be impossible to know the true nature and representativeness of a sample, the palaeodemographer should attempt to determine likely sources of (and the effect of) bias and try to compensate for it (Jackes, 2011: 111). Until the development of better methods, or at least better ways of compensating for bias are established, osteological palaeodemography will always be problematic. However, this does not mean that attempts to reconstruct age at death profiles should be abandoned, particularly where the only data available is osteological. As with all archaeological research, efforts should always be made based on the best available methods and data, until such a time should arise that these efforts can be improved upon.

5.2. Distribution of Burials

Although not the main focus of this study, the work conducted on burial location as part of the reassessment of the population size, combined with the spatial density analysis of the burial areas provides an insight into the formation of the cemeteries. As cremated material was found in all three of the designated main cemetery areas, this suggests the continued use of all the same cemetery areas after the transition from cremation to inhumation. Generally, the observed distribution of cremation and inhumation burials suggests that inhumation burials were more likely to be located closer to the town, and in higher density. Whether we can infer from this that earlier burials were deliberately located further away to allow for town expansion is unclear: interpretations based on data from cremation burials are limited because of the small number of these burial types and lack of information pertaining to older discoveries. Furthermore, until more burials have been subjected to more precise dating and a better chronological burial sequence has been established, it is difficult to make precise interpretations regarding changes and development in burial practices over time.

The spatial density/burial location analysis also reaffirms the notion that the area around the south west road (between York and Tadcaster) was the preferred burial area. Burial density and frequency in this area are higher, and the majority of *in situ* tombstones and coffins were located here. More of the perceived “wealthier” graves are also located along this road. The burial data may therefore suggest that the south west road was the most frequently used road in and out of the town. If the whole purpose of being buried by the road side was to facilitate regular public viewing of funerary monuments, it stands to reason that monuments would be most visible on routes with the highest volume of traffic. The more people travelling along a road, the more desirable that road would be as a cemetery area. After Tadcaster, the south west road is known to have headed towards Lincoln (via Castleford and Doncaster), where it then branches off in several directions towards other significant settlements such as Leicester and London (although Lincoln could also be reached via the south eastern road out of York, anyone travelling this route would first have to cross the Humber Estuary via ferry at Brough: De la Bédoyère, 2003: 79). It is likely that the south west road was therefore the most frequently travelled because it was one end of the main route between *Eboracum* and all other Roman settlements to the south. Following this same logic regarding preferential burial areas and volume of road traffic, the burial data would then suggest that the next most frequented road was the south east road (towards Brough), then the north west road (towards Aldborough, Catterick and ultimately, Hadrian’s Wall). The north east road (towards Malton and the east coast) is not associated with very many burials, potentially indicating that it was the least travelled.

What of the burials located within the settlement areas? This study has found evidence of 10 burials plus disarticulated bone within the confines of the *canabae*, at least 11 burials plus disarticulated bone within the *colonia*, and two burials under the fortress (see Appendix 1 for a list of these sites). It has previously been posited that these may represent burials made before the establishment of the overlaying areas. This is currently difficult to qualify, as only one burial has been dated (c. late first/early second cremation burial found at Exhibition Square; RCHME, 1962: 72), and even then there is little information about how this date was assigned. Interestingly, all skeletal remains except for those at Exhibition Square are unburnt, indicating they are more likely to post-date the first century. Rather than pre-dating the town, it is equally possible that these burials relate to the later period. Whatever the cause, the late fourth century appears to have heralded a period of change and decline in *Eboracum*, and these burials may reflect the beginning of a change in attitude to burial, or simply a more convenient location for disposal. Once again, until these burials are dated securely, their interpretation will be subject to conjecture.

5.3. Dietary Composition

It should be stated outright that there are a multitude of factors, not just diet, that affect the prevalence of the dental pathological conditions discussed in this study. Discussing every possible cause of each of these is beyond this project's scope. However, diet is one of the major factors that contribute to the presence and prevalence of many dental pathological conditions (Moynihan, 2012: 99, Noble, 2012: Ch. 7). So, while the author acknowledges that the observed dental pathological conditions have complex aetiologies, and that other factors may have been causative or contributory, diet is one of the main causal factors and is what this section will focus mainly on. One of this study's aims is to observe prevalence of dental pathological conditions, and determine the type of dietary patterns that are likely to have caused these rates. Furthermore, as the majority of dentate skeletons were unburnt/from inhumation burials, it should be acknowledged that dietary findings are again more likely to relate to the mid/later period of occupation.

High calculus prevalence observed in this study has been used to suggest that the population of *Eboracum* had a diet rich in fat, protein and carbohydrates. But how does this supposition correspond to other evidence for diet and food sources in the town? In an omnivorous diet, protein can be derived from both plant and animal sources. Meat, fish, eggs and dairy products are all common sources of animal based protein, while wholegrain, cereals, legumes, nuts and seeds can provide plants based proteins (Steinke *et al.*, 1991: 91-100; Young and Pellett, 1994). Archaeological evidence from *Eboracum* has suggested that the primary sources of protein in the town were meat and grain, namely beef and spelt wheat (Addyman, 1989: 248-9; O'Connor, 2000: 45). Fat and carbohydrates could also be provided by these sources. The fat content of any meat varies according to factors such as species, breed, location of the cut of meat, and methods of butchery and cooking. Spelt wheat comprises approximately 57.8% carbohydrates, 17% protein, and 3% fat (Gabrovská *et al.*, 2002). Alternative sources of fat would have included dairy products and olive oil (O'Connor, 2000: 51; Ottaway, 2004: 55).

Faunal assemblages from *Eboracum* are heavily dominated by cattle bones, with butchery and tool marks suggesting that shoulder cuts of beef were being smoked and/or salted, and that marrow was extracted from the long bones (possibly for use in stocks and stew; Davies, 1971: 127; O'Connor, 1988; 2000: 45, 54-5). Faunal data also suggests consumption of mutton, pork, venison, goose, and (rather contentiously) dormouse, but in much lesser quantities (O'Connor, 2000: 46 and 49). Evidence from isotopic studies cannot distinguish between species of animals being consumed; however, enriched N^{15} values in the Roman population of York may result from consumption of pork that has been reared on other animal protein (Müldner, 2005: 695).

Beef does not appear to have been an important dietary component in Imperial Rome, with pork seemingly preferred as a higher status meat (King, 1999: 171; 189). However, dietary patterns vary across the rest of the Empire, according to factors such as region, climate and topography (King, 1999: 188). Evidence from faunal assemblages has suggested that beef was more popular at Roman military sites in central and north western Europe, becoming increasingly popular in the later Roman period (Davies, 1971: 137; King, 1999: 178). The predominance of beef at *Eboracum* also conforms generally to findings from other Roman military sites in the north of England, as well as findings from *Londinium* and *Verulamium* (Davies, 1971: 126; Milne, 1995: 109; King, 1999: 178; O'Connor, 2000: 57; Niblett, 2001: 106; McCarthy, 2005: 61). It is well established that pre-Roman

Iron Age populations in Britain were heavily reliant on sheep, so the shift to mature cattle is probably related to the arrival of the Roman army (King, 1999: 178; Albarella, 2007).

The dominant grain represented in archaeological deposits pertaining to the Roman period in York is spelt wheat, found in both charred and waterlogged deposits at sites along the River Ouse (Hall and Kenwood, 1976; Addyman, 1989: 248-9; Hall, 2000: 27; Smith and Kenward, 2012). Other grains present include barley, oats and rye, though overall these are in much smaller quantities (Addyman, 1989: 248-9; Hall, 2000: 36). It is likely that spelt wheat was used to make foods such as bread, porridge and gruel, as well as possibly being used in brewing (Renfrew, 1985: 22; Stevens, 2008: 3; MacKinder, 2010). Wheat may also have been used to produce a starch called *amulum*, which could be used to thicken sauces (Renfrew, 1985: 23).

Spelt wheat has been an important cereal in central Europe since the Neolithic (Harlan, 1992: 166). Archaeological evidence for spelt in Europe during the Roman period is somewhat sparse. However, epigraphic sources suggest spelt was adopted by the Romans after the conquest of Germany: spelt is described by Pliny as a “poor food” only to be eaten “to avert starvation” (Harlan, 1981: 11). Spelt is also documented as being one of the grains utilised in Rome’s first welfare system after the food riots in 59 B. C. (Harlan, 1981). Roman sites in Britain (particularly in the north) frequently demonstrate spelt wheat as the dominant grain, with smaller quantities of emmer, bread wheat, barley and oats (Helbaek, 1963; Davies, 1971: 133; Huntley and Stallibrass, 1995: 37-42, 123-33; McCarthy, 1995; Monckton, 1995: 35-6; Murphy *et al*., 2000: 41; Alcock, 2001: 17; McCarthy, 2005: 61). Again, the predominance of spelt at *Eboracum* conforms to general findings from the north of Roman Britain.

Fat intake is also likely to have come from olive oil and dairy products. Fragments of amphorae found at a number of sites in *Eboracum* indicate that olive oil was being imported to the town from Spain (Ottaway, 2004: 55). Olive oil is regarded as a staple part of the Roman diet, although the oil and its by-products were also used in the production of various fuels, cosmetics, fertiliser, lubricants and other commodities (Mattingly, 2002: 225). Production of olive oil increased significantly in scale between 200 B. C. and 200 A. D., with Rome's supply being supplemented by imports from Spain and Africa (Mattingly, 2002: 218; Temin, 2006: 137). Evidence from fragments of stamped amphorae suggests that military sites along Hadrian's Wall were being supplied with olive oil largely from the *Baetica* region of Spain (modern day Iberia: Funari, 1996: 86). Oil amphorae from the *Baetica* region, dating from the first-third centuries A. D. are commonly found all over the Western Roman Empire (the main concentrations being in Germany, France, and Britain, as well as Rome), and may have been supplied by the State (Woolf, 1992: 286; Remesal Rodríguez, 2002: 300-1). Evidence from writing tablets at Vindolanda show that olive oil was being imported to the site for consumption by soldiers (Funari, 1991; Birley, 2002: 92). Thus, it is probable that olive oil was being imported to *Eboracum* from southern Spain by the Roman army.

The age at death profile (a mixture of young and older animals) of sheep in the faunal assemblages at *Eboracum* suggests that they were more likely to be kept for dairying than for meat (Payne, 1973; O'Connor, 2000: 51). Literary evidence shows that sheep and goats milk was being drunk in the Mediterranean during the Roman period, as well as being turned into products such as cheese: Pliny, Varro, Virgil and Cato are just a few of the writers who refer to dairying, with Cato also stating that cheese was often made out of sheep's milk (McCormick, 1992: 207; Alcock, 2001: 59). Cheese has been considered as another of the basic rations provided for the Roman military and soldiers may have manufactured it themselves (Davies 1971: 125-7; Alcock, 2001: 60). Tentative evidence suggests cheese may have been manufactured in Britain before the arrival of the Romans, although the first explicit evidence does not appear until after the conquest (Fox *et al.*, 2000: 3). Ceramic vessels attributed to dairying (e.g. straining, pressing) have been found at sites all over Roman Britain, although none are known from *Eboracum* (Alcock, 2001: 60-1).

Archaeological, epigraphic and literary evidence therefore corroborates the suggestion that high levels of dental calculus at *Eboracum* may have been caused by consumption of foods rich in fat, protein and carbohydrates. More specifically, these foods are likely to have been meat such as beef, grains such as spelt wheat, and products such as olive oil and cheese. Foods such as these are likely to have been readily available to both soldiers and civilians at *Eboracum*, and may even have been dietary staples.

Low prevalence of dental caries and ante-mortem tooth loss has been used to suggest that the population of *Eboracum* were consuming fewer foods containing sugar and starch and fermentable carbohydrates, especially compared to other populations at other Romano-British urban sites. Types of sugar that are highly likely to cause dental caries and possibly facilitate ante-mortem tooth loss include sucrose, fructose, lactose, and glucose (Hillson, 1996: 278). However, studies have indicated that starch alone is not as cariogenic as once thought; starchy foods may only have a cariogenic effect when consumed in large quantities and when combined with increased sugar consumption (Rugg-Gunn *et al.*, 1987, Moynihan, 2012: 107). The combination of sugar and starch together is considered to be more cariogenic than sugar alone (Bibby, 1975). Therefore, if consumption of sugar was low in *Eboracum*, starch is unlikely to have had a significant effect on the prevalence of dental caries and subsequent ante-mortem tooth loss.

Recent clinical work has shown that while all types of sugar are cariogenic to some extent, glucose and sucrose are typically more cariogenic, while lactose is less so. (Milgrom and Ly, 2012: 146; Moynihan, 2012: 106). Glucose, fructose and sucrose all occur naturally in plants, fruit and some root vegetables (Tull, 1996: 9). Fructose and glucose also occurs naturally in cane sugar and honey, and lactose in milk (Insel *et al.*, 2012: 138; 148). However, sugars that occur naturally in vegetables, fruit, milk, cheese and grain are not typically cariogenic (Moynihan, 2012: 108). Roberts and Cox (2003: 134) have suggested that increase in caries prevalence in Roman Britain may have been partly due to increased consumption of dried fruit such as figs and dates. Clinical studies have shown that dried fruit is more likely to be cariogenic than fresh fruit, as the drying process changes the composition of the fruit and releases more sugars (Moynihan, 2002: 565). In view of this, the most cariogenic foodstuffs available in *Eboracum* are likely to have been dried fruit, honey, and foods containing sugar and/or syrup.

While archaeobotanical evidence shows us the range of fruits being consumed in *Eboracum*, this evidence cannot distinguish between fruits that are fresh or dried. Nor can it tell us the quantities in which these fruits were being consumed. Fortunately, literary evidence can give an indication of the types of fruits that would probably have been dried and observe whether these species are present in archaeological assemblages. The majority of fruits present in archaeobotanical assemblages from *Eboracum* are more likely to have been fresh; fruits such as elderberries, blackberries and sloe were probably collected from wild plants rather than being cultivated (Hall, 2000: 38). Fruits imported to Britain are likely to have been dried in order to preserve them so that they would survive the long journey without spoiling (Wilson, 1976: 291; Alcock, 2001: 67). Commonly dried fruits consumed in the Roman Empire included figs, dates and raisins (Wilson, 1977: 291; Kujiper and Turner, 1992: 198; Van der Veen, 2008: 12). No evidence of date consumption has been found in *Eboracum*. While grape seeds have been found in archaeobotanical assemblages from *Eboracum*, it is unknown whether the fruits were dried or fresh (Hall, 2000: 38). Fig seeds have been found at sites such as Coney Street, and currently provide the most substantial evidence for the presence of dried fruit in *Eboracum* (Dickson and Dickson, 1996: 624; Hall, 2000: 38).

Literary evidence suggests that dried figs were commonly eaten in Roman Italy; both Columella and Pliny list dried figs as a dietary staple (Bakels and Jacomet, 2003: 554). Fig seeds are frequently found on Roman period sites across the Empire, suggesting they were a common food source (Wilcox, 1977: 281; Hamel, 1990: 2; Bakels and Jacomet, 2003: 547). Earlier examples of fig seeds found outside Italy occur at military installations such as Vindonissa in the Netherlands, support the idea that dried figs were carried by the Roman army as part of their rations (Roach, 1985; Greig, 1991; Bakels and Jacomet, 2003: 554; Clapham, 2003: 5). This may also explain the relative abundance of the seeds in Roman Britain, found at multiple sites such as London, Silchester, Verulamium, and at numerous military sites along the Antonine Wall (Wilson, 1976: 291; Wilcox, 1977: 278-9; Dickson and Dickson, 1996: 624; Alcock, 2001: 67; Van der Veen, 2008). Honey was probably the primary source of sugar in Roman diets: half of the recipes in the late Roman cookery book by Apicius (late fourth - early fifth century) include honey (Allsop and Miller, 1996: 516). Such recipes show that honey was used to sweeten food, or to counteract sour or sharp tastes (Alcock, 2000: 76). It was smeared over meat and fish, used to preserve meat and fruit, to sweeten wine, and make honey beer, and it was also used in sauces and dressings (Wilson, 1976: 249-50, 291 and 329; Garnsey, 1999: 118; Alcock, 2000: 76). Numerous contemporary texts exist discussing methods of bee keeping, with Columella, Virgil, Varro, Pliny and Celsus just a few of the writers who give advice on subjects such as the best way to construct hives and uses for honey (honey was also used medicinally as it was thought to have antibacterial properties; Wilson, 1976: 250; Alcock, 2000: 76).

As with evidence for cheese production, the archaeological evidence pertaining to beekeeping and honey is limited and sometimes open to interpretation. Possible material evidence for extraction of honey has been found in the form of ceramic pots, whose perforated bases may have allowed honey to drain out of the comb and into a dish below; such vessels have been discovered at Silchester and Templeborough (Alcock, 2000: 76). Probably the best evidence for the presence of honey comes from the military installation at Vindonissa, where inscriptions on amphorae record the volume of honey being stored (Davies, 1971: 131). No evidence of honey has been found at *Eboracum*. This does not mean that honey was not present at the town at this time. Materials associated with beekeeping and production of honey may simply be archaeologically invisible, e.g. honey could be drained out of the comb using woven cloth that would not survive archaeologically (Alcock, 2000: 76).

Sapa is a grape juice concentrate frequently quoted as being used in the Roman Empire to sweeten food and wine, and also to keep it from spoiling (Lessler, 1988: 80; Sealey, 2009: 28). It is produced by boiling grape juice in a lead-lined vessel until it is reduced to syrup: it is thought that it is the addition of lead at this stage that acts as a preservative (Lessler, 1988: 80; Skovenborg, 1995: 50; Garnsey, 1999; 139). References to *sapa* are frequently found in Roman literature, with recipes and uses for the syrup described by Columella (in the first century A. D.), Pliny and Apicius (Eisinger, 1982: 284-5; Starr, 2009). Although there is little material evidence for *sapa* consumption in the archaeological record, amphorae of the typology commonly associated with transportation of *sapa* (Baetican amphorae of type Haltem 70) have been found at sites in Britain, including at *Eboracum* (Carreras Monfort, 1998: 165). Furthermore, dietary lead may be partially responsible (other possible contributory factors include drinking water that had been carried via lead piping) for elevated lead isotope ratios found in human skeletal remains from Poundbury in Dorset and other sites such as Cirencester (Waldron *et al.*, 1976; Waldron *et al.*, 1982; Molleson *et al.*, 1986). Similar elevated ratios have been found in a sample of skeletons from Trentholme Drive at *Eboracum* (Mackie *et al.*, 1975).

The aforementioned evidence suggests that the population of *Eboracum* did have access to sugary foodstuff such as dried fruit, and potentially honey, and syrups such as *sapa*. However, there is no evidence to suggest the quantities in which these products were being consumed. Nonetheless, the low prevalence of dental caries in this population may suggest that people were eating these foods less frequently and/or in smaller quantities than at other urban sites in Roman Britain.

One of the main factors contributing to prevalence of ante-mortem tooth loss is presence/development of dental caries, which (as established above, page 280) largely develop as a result of sugary dietary components. Clinical studies have suggested that individuals who lose teeth change their dietary habits as a result. Excessive tooth loss may also have facilitated dietary change. As tooth loss occurs, masticatory efficiency and chewing ability declines, which in turn is likely to influence choice of food for consumption (Hutton *et al.*, 2002: 183; Nowjack-Rayner and Sheiham, 2003; Hung *et al.*, 2005: 172). Harder foods such as raw vegetables, raw fruit and meat can become increasingly difficult to chew as fewer teeth are present (Hutton *et al.*, 2002: 183).

These foodstuffs may therefore become a reduced dietary component; clinical studies have shown that in modern populations, individuals with fewer teeth are less likely to eat fruit, vegetables, meat and foods containing fibre (Wayler and Chauncey, 1983; Brodeur *et al.*, 1993; Johansson *et al.*, 1994; Joshipura *et al.*, 1996; Hutton *et al.*, 2002; and Hung *et al.*, 2005). Intake of nutrients has also been found to decrease significantly as more teeth are lost (Sheiham *et al.*, 2001). In modern populations, these dietary components are likely to be substituted by softer, processed foods that are higher in calories, saturated fat and cholesterol (Joshipura *et al.*, 1996; Hutton *et al.*, 2002; Hung *et al.*, 2005: 170). This type of dietary change is likely to have a bearing on systemic health, and increasing susceptibility to conditions such as cardiovascular disease, cancer, and diabetes (Hutton *et al.*, 2002: 185; Walls and Steele, 2004; Hung *et al.*, 2005: 172). Although these findings have not been tested with regards to applicability to past populations, and it should be acknowledged that past populations did not have access to the same processed, soft foods that are available to modern populations, it could still be inferred that tooth loss could facilitate similar changes in diet in the past.

The aforementioned clinical studies suggest that significant dietary and nutritional changes are more likely to occur after the loss of five or more teeth. In the population from *Eboracum*, approximately 90% of the observed population had lost fewer than five teeth. This may suggest that the 10% of the population with excessive ante-mortem tooth loss would be less inclined to eat harder foods such as raw fruit and vegetables and meat. Social and economic factors (e.g. social status, wealth, food type and availability) are likely to have significant influence on what could replace these foodstuffs. The type, quantity and nutritional value of the substituting food would then impact upon the health status of each individual. These findings suggest that a small proportion of the population of *Eboracum* are likely to have changed their dietary habits as the result of tooth loss.

There is also evidence to suggest that diet in Roman York may not have been as abrasive as expected. Peck's (2009) study considered occlusal wear in a sample of individuals from the Trentholme Drive assemblage from Roman York. The results suggested that attrition and abrasion did not have a significant effect on the observed pattern of dental pathology, despite the usual assumption that Romano-British populations were consuming products such as coarse grained wholemeal bread (Peck, 2009: 171) (although factors such as method of flour preparation would have an influence on coarseness of flour/bread, and these factors are likely to vary temporally, and geographically and so on, e.g. whether flour was produced by hand at home, or imported from elsewhere, type of quern or millstone used for grinding etc; Niblett, 2001: 107; Rees, 2011: 111-3). However, Peck's (2009) study found that levels of wear were not significantly different from those observed in a comparative Iron Age population from four archaeological sites (Rudston, Burton Fleming, Garton Station and Kirkburn) in East Yorkshire, who are believed to have been consuming a much softer diet (Peck, 2009: 170-1). These findings may suggest that either the Romano-British population were consuming more softer foods/fewer abrasive foods, or that the preceding Iron Age population were consuming fewer softer foods/more abrasive foods than expected (e.g. fibrous meat or other animal products; Peck, 2009: 170).

Whatever the case, the aforementioned evidence tentatively suggests that diet in Roman York may have been less abrasive than originally thought. However, dental analysis examining coarseness of diet in the present project was relatively simple, and the sample available was also small. Additionally, rather than this analysis indicating that diet was softer, differences in age estimated using dental versus pelvic aging methods could simply reflect the differential accuracy of the methods. More conclusive results could be gained from a larger, more comprehensive investigation of this subject, or by investigating dental microwear.

To summarise, the relatively low incidence of dental caries (in conjunction with low rates of ante-mortem tooth loss) supports the notion that on the whole, the population of *Eboracum* were not consuming as much sugar as other urban populations during this period. A small group of individuals exhibited excessive tooth loss. This may have been the result of factors such as age and individual dietary differences. These differences may be influenced by socio-economic factors, e.g. social status and associated wealth. Furthermore, diets that are high in fat and protein (as well as diets high in phosphorus and calcium) are often associated with low rates of dental caries (Hillson 1996: 279), which also fits with the aforementioned dietary patterns that may also be responsible for high prevalence of calculus in this population.

Before diet is discussed in relation to periodontal disease, it should be stated that the high rates of dental calculus observed in this population are likely to have influenced rates of periodontal disease. Accumulation of plaque around the cemento-enamel junction of the tooth gradually leads to irritation and eventual destruction of the surrounding soft tissues (Rugg-Gunn, 1993: 304-9; Hillson, 1996: 260-3). This process has been proved to be crucial in the occurrence in the development of periodontal disease, particularly when allowed to continue for a lengthy period of time (Rugg-Gunn, 1993: 304-9). Recent clinical studies have suggested that nutrition is likely to play a role in the development and severity of periodontal disease (Nishida *et al.*, 2000; Chapple *et al.*, 2007; Yu *et al.*, 2007; Moynihan, 2012: 100), and it is this relationship that will be considered in relation to implications for diet in this section. However, the role of calculus formation/severity in development of periodontal disease should not be forgotten.

If dietary factors are causal/contributory to observed levels of periodontal disease, high prevalence of the condition at *Eboracum* may suggest that the population was not consuming sufficient quantities of nutrients such as vitamin C, calcium, and antioxidants. Subsequently, this may suggest that individuals were not consuming enough fresh fruit, vegetables and whole grains, which are all good sources of vitamin C and antioxidants. This chapter has already established that one of the dietary staples in *Eboracum* is likely to have been spelt wheat. Therefore, while insufficient whole grain consumption may contribute to the development of periodontal disease, it is unlikely that this is the case for the majority of this population. This section will, therefore, focus on evidence for the consumption of fresh fruit and vegetables.

The only evidence for fresh fruit and vegetables in *Eboracum* comes from charred seed assemblages. Hall’s (2000) study of evidence for food in the town suggests that apples and cherries may have been cultivated nearby, with fruits such as hawthorn berries, strawberries, sloe, blackberries, elderberries, bilberries and raspberries being collected from wild plants. As discussed previously (page 281), dried figs and grapes as well as olives and black mulberries, were probably imported from the continent (Hall, 2000: 38 and 40; Van der Veen *et al.*, 2008: 25). The only evidence from *Eboracum* for vegetables comes in the form of carrot seeds, although Hall (2000: 32, 40) points out that the presence of these few seeds may be from imported hay or herbivore dung, rather than being related to consumption by humans. Unfortunately, the archaeobotanical assemblages collected for York are very small, so while they may be indicative of potential dietary breadth, they do not give us any indication as to the quantities in which various fruits and vegetables might have been consumed (Hall, 2000).

There is evidence for a broader range of fresh produce in the rest of Roman Britain, although it should be noted that data are heavily biased towards finds from towns, particularly London (Van der Veen *et al.*, 2007: 185). Furthermore, much of the available data is poor in quality, and potentially difficult to access because of the preponderance of reports taking the form of unpublished grey literature (Van der Veen *et al.*, 2007). However, published data show that seeds of imported strains of fruit and vegetables including fig, grape, mulberry, olive, peach, date, pomegranate, pear, cherry, plum, damson, cabbage, turnip, leek, cucumber, carrot, parsnip, lettuce and asparagus have all been found at Romano-British sites (Van der Veen *et al.*, 2008: 13). Evidence for wild gathered fruit is also found (Knights *et al.*, 1983: 143). Vegetables are more prevalent at rural sites, and while fruit appears evenly distributed across different types of site, their remains are less frequent than the remains of herbs and seasonings such as coriander and dill (Van der Veen *et al.*, 2008: 27-8). Some fruits tend to occur more frequently at urban or military sites, e.g. figs, grapes and olives (Van der Veen *et al*., 2008: 32). The Roman expansion into Britain appears to have broadened the range of fruit and vegetables available to everyone, even poor, low-status members of the population. However, the available archaeobotanical evidence is still incapable of demonstrating the quantities in which these foods were consumed.

Evidence for the rest of the Roman Empire is also limited, and very few reports examine data from more than one site. Generally, findings suggest that there was a broad range of fruit and vegetables available throughout the Empire, with variations according to location, climate, topography, and so on. Roman conquest probably introduced new varieties of species that were already available (Bakels and Jacomet, 2003: 554-5). Vegetables are likely to have been provided as part of standard military rations. Archaeobotanical evidence from the military site of Vindonissa shows the soldiers were probably subsisting on vegetables such as peas and carrots, as well as pulses (Davies, 1971: 133). At the legionary fortress at Neuss, remains of vegetables present in the archaeological record included peas, carrots, broad beans and garlic (Davies, 1971: 133-4). Presumably rations and the diet of soldiers would have varied according to location, what was available, and also factors such as rank, social status and wealth. For example, Bakels and Jacomet’s (2003) study of luxury foods during the Roman period shows that, although they are abundant in the Mediterranean, in Central Europe olives are found almost exclusively at military sites. Rare fruits such as dates, pomegranate and melon occur occasionally but only at “Romanised” sites e.g. Vindonissa (Bakels and Jacomet, 2003: 553-4). These could represent exotic imports from the Mediterranean or be the result of experiments in cultivation (Bakels and Jacomet, 2003: 553-4).

The aforementioned evidence suggests that the range of fruits and vegetables available in *Eboracum* was a combination of (a small amount of) imported produce from elsewhere in the Empire, locally cultivated products (that may have included both local and foreign species of plant) and also locally gathered wild fruits. Fresh fruit was difficult to import because of spoilage, so plant remains from non-local species are likely to be from dried foods (e.g. figs) or of locally cultivated strains of imported species. Evidence from elsewhere in Roman Britain indicate it is likely that all strata of society in *Eboracum* would have access to some form of fresh produce. The types of fruit and vegetables present at *Eboracum* show a moderate available range of fruits and vegetables, which also conforms to general patterns observed at other Romano-British urban and military sites. However, the limited archaeobotanical evidence cannot corroborate or refute the suggestion made by the present study, higher observed rates of periodontal disease may indicate that fruit and vegetables were only consumed in small quantities, or were a small dietary component in Roman York.

Just over half of the population of *Eboracum* had enamel hypoplastic lesions, and significantly more teeth were affected by these lesions than is expected for the period. The results indicate that a large proportion of the population are likely to have been affected by nutritional stress during childhood. Presence of enamel hypoplasia has previously been associated with weaning (Cook, 1979; Skinner and Hung, 1989; Lanphear, 1990; Rugg-Gunn, 1993: 340-1; Blakey *et al.*, 1994; Moggi-Cecchi *et al.*, 1994; Katzenberg *et al.*, 1996). However, it is unclear whether studies demonstrating a positive relationship between enamel hypoplasia and weaning are simply correlational rather than causative (Katzenberg *et al.*, 1996: 185-7). Therefore, this study will not consider presence of enamel hypoplasia in regards to weaning practices. Furthermore, while the author recognises that nutritional stress may be related to non-dietary factors such as malnutrition, disease load, and parasites that can inhibit uptake of nutrients, this section will discuss presence of enamel hypoplasia in regards to vitamin deficiency.

Clinical studies have suggested that enamel hypoplasia can occur as a result of insufficient uptake of Vitamin A, Vitamin D and/or protein (Moynihan, 2012: 100). This must occur during childhood, when the enamel layer of the tooth crown develops. Permanent tooth crowns tend to form between birth and approximately eight years of age, although molar crowns (particularly the third molar) may develop at a later age (Moorees *et al.*, 1963). Therefore, presence of enamel hypoplasia may be indicative of a period of nutritional stress at any time during this age range. A more specific age range may be ascertained according to tooth type and location of the lesion, after Reid and Dean (2000), although this type of analysis was not carried out for this study. Earlier sections of this chapter have indicated that the population of *Eboracum* were eating sufficient quantities of protein, so protein deficiency during childhood is unlikely to have contributed significantly to the observed rates of enamel hypoplasia. We will now consider whether children of this age are likely to have been obtaining sufficient quantities of Vitamin A and Vitamin D.

Vitamin A is chiefly found in animal liver, as well as fresh fruit, vegetables, oily fish and some dairy products. Currently, archaeological evidence cannot demonstrate whether animal liver was utilised as a food source. In terms of written references, liver is mentioned as an ingredient in Roman recipes, and may have been considered by some as a delicacy (e.g. by Galen, writing in the second century; Garnsey, 1999: 83-4). Consumption of liver is also recommended by authors such as Aetius Amidenus (writing in the sixth century A. D.) as a cure for eye diseases (Garnsey, 1999: 46-7). Unfortunately it is difficult to demonstrate whether liver was utilised as a food source in Roman Britain. As for other sources of Vitamin A in *Eboracum,* it has already been suggested that the population were not consuming sufficient quantities of fresh fruit and vegetables, which could contribute to some people being deficient in this particular nutrient. Dairy products were probably being consumed, and fish bone and stable isotope evidence indicates that marine fish such as herring was a small but regular dietary component (Ottaway, 2004: 105; Müldner and Richards, 2007). Despite the probable low fruit and vegetable intake, the population of *Eboracum* were probably consuming Vitamin A in sufficient quantities during childhood.

Vitamin D can be obtained via both exposure to sunlight and diet. Current National Health Service (2011) guidelines recommend that in Britain, 15 minutes per day exposure to the sun (in summertime) is sufficient to obtain sufficient quantities of Vitamin D, although the amount of the vitamin produced may vary according to factors such as age and skin colour. However, Vitamin D production in Britain during winter (November to March) can be severely inhibited because of inadequate levels of ultraviolet B (UVB) in the available sunlight, so more of the vitamin must be acquired through dietary uptake (NHS, 2011; Ross *et al.*, 2011).

Furthermore, Vitamin D uptake will also be inhibited by clothing (presumably more/thicker clothing would be worn during colder months), spending more time indoors (again, during the winter months) and social and/or cultural practices that prevent or restrict skin exposure may also exacerbate the problem (Roberts and Cox, 2003: 142). Garnsey's (1993: 57) discussion of child rearing practices in Roman Italy, for example, suggests that infants were at increased risk of Vitamin D deficiency (and subsequent disorders such as rickets) as a result of Roman women with young children being inclined to stay indoors, and also swaddle their children for the first three month of life. Although this discussion focuses on Roman women residing in Italy, transfer of such practices to other locations in the Empire is certainly possible, considering the extent of population movement and migration occurring in Europe during the Roman period. Practices such swaddling of children, and young mothers being more inclined to stay indoors, would undoubtedly reduce there individuals exposure to sunlight, and potentially inhibit uptake of Vitamin D (also see Garnsey, 1999: 53; Lewis, 2010: 413).

Very few foods naturally contain Vitamin D, and many food products high in the vitamin in the modern period contain artificial supplements (Institute of Medicine, Food and Nutrition, 2010). Oily fish, mushrooms and some dairy products (e.g. egg yolks) are natural sources of Vitamin D, but the amount present is variable and often small (Institute of Medicine, Food and Nutrition, 2010). Additionally, dried fruit may have enhanced Vitamin D levels if it has been dried naturally in the sun (Roberts and Cox, 2003: 142). The aforesaid oily fish and dairy produce does seem to have been at least a minor dietary component at *Eboracum*. While there is no known evidence for consumption of mushrooms at *Eboracum*, edible fungi were available in Roman Britain, e.g. wild puffball mushrooms are known to have grown at Vindolanda in the first century A. D. (Alcock, 2001: 65). Thus, the population of *Eboracum* are likely to have had sufficient vitamin D intake in the summer months due to exposure to sunlight. In winter months, however, when sun exposure was unlikely to produce adequate levels of Vitamin D, food sources containing small amounts of this were probably available. While it is unknown whether these would have been consumed in sufficient quantities to fully supplement daily requirements, the absence of evidence for rickets or osteomalacia (distortion of the bones as a result of insufficient intake/absorption of Vitamin D; Aufderheide and Rodríguez-Martin, 1998: 305-10) also suggests that the population were acquiring sufficient quantities of Vitamin D.

High prevalence of enamel hypoplasia in the population of *Eboracum* is likely to be the result of interplay between a number of factors, one of which of which is childhood dietary intake (for individuals who were born and raised in *Eboracum*; see pages 312-3 for further discussion on enamel hypoplasia and other pathological conditions related to childhood and the presence of migrants that may have spent their childhood elsewhere). The aforementioned evidence for consumption of meat indicates that protein deficiency is unlikely to have been a problem, as beef appears to be a staple source of food. Similarly, the majority of the population are likely to have been consuming enough types of food to supply them with the required amount of Vitamin A. However, it is much more difficult to demonstrate whether the population would have been receiving sufficient quantities of Vitamin D. Therefore, if high prevalence of enamel hypoplasia is partially related to diet, it is most likely to be due to insufficient consumption of Vitamin D during the winter months, when ample quantities cannot be obtained through exposure to sunlight.

In summary, osteological results for rates of dental calculus corroborate isotopic, archaeobotanical and zooarchaeological evidence for diet in *Eboracum*. Dietary staples in the town appear to have been spelt-based products such as bread, and beef. A combination of osteological, isotopic, archaeobotanical, zooarchaeological and literary evidence indicates that other dietary components are likely to have included dairy products such as sheep’s milk and cheese, olive oil, dried figs and fish. Observed rates of dental caries, ante-mortem tooth loss and periodontal disease suggest that people were probably not consuming enough fresh fruit and vegetables, despite a rather broad range being available. It is also likely that the populace were consuming lesser quantities of sugary products containing honey and syrup. These dietary patterns are more likely to apply to the later period of occupation in *Eboracum*, largely because of the paucity of available human skeletal remains relating to the earlier period. Evidence for concerning breadth of diet therefore broadly supports findings from Poundbury, where stable isotope analysis showed that diet became more varied in the later Romano-British period (Richard *et al.*, 1998). Unfortunately, this study is unable to distinguish any possible difference between military and civilian diet, again because it is extremely difficult to distinguish between military and civilian burials.

These results also contradict Peck’s (2009: 184) suggestion that there was a decrease in dietary breadth after the Roman conquest of Britain. The aforementioned sources of evidence strongly suggest that the arrival of the Romans brought new strains of plant foods, and those that could not be grown here were imported, as were more exotic foods such as wine and olive oil. Dairying is also likely to have been undertaken on a much larger scale than in the preceding Iron Age. Even though these food sources may not necessarily have been introduced to Britain and its native population immediately after the arrival of the Romans, it is apparent that diversification of food sources and subsequent dietary breadth would have occurred as time progressed. Furthermore, Peck (2009) also concludes that the amount of cariogenic foodstuffs being consumed in *Eboracum* was greater than in the preceding Iron Age. Although this is likely to be a general trend across Roman Britain, this study clearly demonstrates that at *Eboracum*, cariogenic foods were still being consumed in significantly smaller quantities than at other Romano-British towns.

5.4. State of Health

The results of this study show that when compared to rates found at other Romano-British urban sites, the vast majority of pathological conditions observed in the population of *Eboracum* fall within the expected (crude prevalence) range for the period. In terms of CPR, the population had significantly elevated prevalence of cranial trauma, post-cranial trauma, and porotic hyperostosis. Prevalence of spina bifida, os acromiale, Schmorl’s nodes, non-specific infection and trauma were also observed as being significantly different between males and females from *Eboracum*. The observation of increased male involvement fits with observed patterns in modern clinical research (Fidas *et al.*, 1987; Eubanks and Cheruvu, 2009). However, it is difficult to ascertain why this pattern occurs, as modern clinical research tends to focus on management and treatment of the more serious forms of the condition. Therefore, male bias of spina bifida will not be considered any further in this chapter. Where possible, this section will discuss reasons for observed significant results and what implications these results have on the pattern of health of the population of *Eboracum*, and at other Romano-British urban sites.

It should be noted at this point, that comparison of joint disease between populations can be extremely problematic because of differential criteria being recorded for this type of pathology between sites. This was certainly found to be the case during the present study. Between the osteological reports available for York, and data available for the comparative towns, problems included use of different terminology and definitions used to describe various types of joint disease (e.g. arthropathy, osteoarthritis, osteoarthrosis, degenerative disc disease, degenerative joint disease, osteophytosis, degenerative osteoarthritis etc; McWhirr *et al.*, 1982: 152; Wheeler, 1985: 277; Crummy *et al.*, 1993: 85; Davies *et al*., 2002: 152; Egging Dinwiddy, 2009: 27). Older osteological reports in particular do not always clarify or define what is meant by whatever term is being used. Further problems between reports include differential methods of recording (e.g. simply stating true or crude prevalence rates with little accompanying raw data, describing the type/location of the lesion but not adhering to a scoring system, recording either per individual, per skeletall element or per joint, not stating which set of recording standards, if any, were used etc.), either inclusion or exclusion of Schmorl's nodes with evidence for spinal joint disease, and differential presentation of raw data. It is for these reasons that all available evidence for joint disease/osteoarthritis was combined for the present study.

Unfortunately, this means that the findings of the present study regarding joint disease/osteoarthritis are very broad and general in scope, and should therefore be regarded cautiously. However, the very crude prevalence rates that have been calculated in this study do suggest that prevalence of spinal and extra spinal joint disease/osteoarthritis does appear to be highly variable between urban sites in Roman Britain. Spinal joint disease/osteoarthritis in particular has the potential for the highest and broadest crude prevalence rates/ranges out of all the observed pathological conditions. This finding should be considered in future studies, with potential to be investigated further between populations that have been recorded using the same, standardised methods.

The single possible incidence of brucellosis in the York population is slightly problematic in terms of interpretation. This one possible case may be a rare example of an infectious disease that is seldom reported in palaeopathological literature. Brucellosis clearly was present in Europe during the Roman period, as demonstrated by archaeological human skeletal remains from Herculaneum and the presence of possible *Brucellae* bacteria in carbonised cheese from the same town (Carpasso, 1999; 2002). Archaeological cases are very rare and often brucellosis is only one of a number of potential diagnoses (Canci *et al.*, 2005; Bendrey *et al.*, 2008). However, this one case has the potential to provide insight into a rarely observed, interesting palaeopathological condition.

Brucellosis is primarily an animal disease, although animal cases (tentative or confirmed, see Bendrey *et al.*, 2008) are rarely reported archaeologically. Where the disease does occur in humans, it frequently affects individuals who have been working with infected animals, e.g. farmers, veterinarians, slaughterhouse workers; *Brucella* bacteria are known to survive in manure, animal urine and even barnyard run-off water (Blank, 2000: 83). Before the invention of pasteurisation, bacteria are also known to have survived in dairy products, potentially infecting consumers (Young, 1995; Corbel, 1997; Aufderheide and Rodríguez-Martin, 1998: 192; Capasso, 1999; Blank, 2000: 83-4). Therefore, an individual exhibiting the skeletal symptoms of brucellosis may have contracted the disease from working with animals, or simply by eating infected milk or cheese.

Aforementioned zooarchaeological evidence has suggested that dairy products such as milk and cheese were being consumed in *Eboracum*. The affected individual was one of a small number of individuals from this study buried more than 3km away from the centre of *Eboracum*. It is tempting to suggest that the burial location of this individual away from the urban centre is indicative that this person belonged to the rural community, e.g. an isolated farmstead. Presumably, animals being reared for meat and milk were kept at sites within the vicinity of the town (possibly within the territorium). In such circumstances a person could contract brucellosis via infected food or day to day dealing with an infected animal. Unfortunately, without further confirmation of the diagnosis, information regarding the individual, the archaeology of the local area, or potential presence of animal rearing farmsteads, this hypothesis remains largely conjecture. Low prevalence in the observed archaeological populations may reflect genuine low prevalence, or low prevalence of cases progressing to skeletal involvement.

Prevalence of os acromiale is elevated, as values for *Eboracum* suggest that the town is a significant outlier in the constructed box and whisker plot (Figure 4.27, page 202). Although no other comparative sites had recorded incidences of os acromiale, it is interesting that so many cases have been observed in the *Eboracum* population. Prevalence of os acromiale does vary between populations (Case *et al.*, 2006). Significantly higher frequencies of os acromiale tend to be found in African Americans, especially in individuals of West or South African ancestry (Sammarco, 2000; Case *et al.*, 2006: 12, 15; Hunt and Bullen, 2007). Lower frequencies are reported in European and North American populations (Sammarco, 2000; Case *et al.*, 2006: 12). Findings from studies such as these have been used to indicate a genetic aetiology for os acromiale, or at least a predisposition to development of the condition in certain populations. As for expected prevalence ranges, anatomical texts have suggested that in modern populations, the condition occurs in approximately 3-8% of individuals (Miles, 1994: 150). Many of these anatomical observations refer to North American or European specimens, and this prevalence range does appear to corroborate results from archaeological studies utilising European and North American archaeological and anthropological specimens (Miles, 1994; Case *et al.*, 2006; Hunt and Bullen, 2007). Moreover, if British and European populations are likely to have a prevalence range of 3-8%, this may suggest that archaeologically observed rates from Roman Britain are lower than expected. This theory would assume that prevalence rates in the Roman period approximate modern rates; until more research is conducted regarding prevalence variation through time, we cannot confirm whether this is the case.

Significant results were also found regarding sex and side distribution of os acromiale, with significantly higher prevalence being found in males, and in the left scapula. As previously stated, the observed sex and side bias strongly supports a mechanical aetiology over genetic predisposition for the condition within the population of *Eboracum* (Case *et al.*, 2006: 13). Therefore, it is suggested that males were more likely to be partaking in activities that placed increased stress on the rotator cuff from a young age, which in turn increased their likelihood of impinged acromial fusion. More specifically, stress to the the deltoid and trapezius muscles and/or coraco-acromial and acromioclavicular ligaments (all of which originate or insert on the acromial epiphysis) would potentially affect development/non-union of the acromion (McMinn and Hutchings, 1988: 92 and 94; Warner *et al*., 1998; Vahlensieck, 2000; Case *et al*., 2006: 4-5). This is not to say that genetic factors should be completely discounted (a combined mechanical/genetic aetiology is yet another possibility), but the combination of both sex and side bias does allude to an activity-related cause.

Development of os acromiale is difficult to relate to a particular activity, and the trait is not occupation specific. Any activity placing stress on the rotator cuff muscles of the shoulder, especially in late adolescence, may contribute to the development of the condition (Coughlan and Holst, 2000: 73). In modern patients, os acromiale is often found in athletes, with clinically documented cases often involving basketball and baseball players, and American footballers (Paley *et al.*, 2000; Pagnani *et al.*, 2006). Presumably individuals who develop os acromiale are more likely to be partaking in such activities from at least adolescence, if not before: the acromiale epiphysis commences fusion at approximately age 17-18 years and should be fully fused in the majority of people by the age of 20 (Case *et al.*, 2006; Schaefer *et al.*, 2009: 164). This evidence therefore indicates that males at *Eboracum* are more likely to be partaking in physical activities during adolescence that may impinge acromiale fusion.

A second pathology with links to activity patterns was also found significantly more frequently in males than females: Schmorl's nodes. The overall distribution of Schmorl's nodes at *Eboracum* correlates with previous findings regarding their location in the spine (Pfirrmann and Resnick, 2001; Dar *et al.*, 2010). Schmorl's nodes are more likely to develop in the (mid to lower) thoracic spine because thoracic vertebrae are more prone to torsional, rotational movement; lumbar torsion is minimal as compared to thoracic torsion (Pfirrmann and Resnick, 2001; Dar *et al.*, 2010: 673). Furthermore, lumbar vertebrae have greater cortical thickness than thoracic vertebrae, giving better resistance to disc herniation (Dar *et al.*, 2010: 673).

Mechanical loading may exacerbate the presence and location of Schmorl's nodes, and torsional movement, in particular, is thought to be a major causal factor (Dar *et al.*, 2010: 673). However, it has also been suggested that Schmorl's nodes are more likely to develop in males, as a result of morphological differences between the vertebrae of males and females (Dar *et al.*, 2009: E314; Plomp *et al.*, 2012). Plomp *et al.* (2012: 579) also suggest caution in using presence, frequency and location of Schmorl's nodes to indicate activity and/or physical stress: this study strongly suggests that development of Schmorl's nodes is in fact linked to normal variation in vertebral shape, with particular shapes predisposing individuals to the biomechanical strain necessary to produce the Schmorl's node lesion.

Sex differentiation in the prevalence of os acromiale may therefore suggest that males and females were partaking in different types of physical activities, i.e. that males were more likely to partake in activities that place stress on the rotator cuff. The male sex bias observed here is interesting to note, particularly as no sex bias was observed in prevalence of spinal or extra-spinal joint disease. Presence of joint disease associated with repeated physical movement is frequently discussed with regards to habitual occupational activity (e.g. Lai and Lovell, 1992; McMillan and Nichols, 2005; Weiss and Jurmain, 2007:442-4). Observations by Brown (*et al.*, 2008) strongly suggest that spinal joint disease in particular is affected by mechanical loading. Repeated mechanical loading (through actions such as heavy lifting; Peck, 2009: 175), would exacerbate pressure on the maximum point of stress within the spine, causing skeletal symptoms frequently associated with spinal joint disease, e.g. osteophytosis. Therefore, a similarity in prevalence of spinal and extra-spinal joint disease between the sexes may also indicates that generally, females were as likely to be partaking in physical labour as their male counterparts.

The men of *Eboracum* have been associated with a variety of occupations, relating to the military, industry, crafts, politics, trade and so on (Ottaway, 2004: 59-61). However, there is very little evidence pertaining to female activity at *Eboracum*: epigraphic references to women are mostly associated with women of higher social status, and tend to focus on their role as a wife and mother (Ottaway, 2004: 117-20). This mirrors epigraphic findings in other Romano-British towns and military sites, where inscriptions (funerary or otherwise) frequently refer to women as "wife of...", "widow of...", "mother of..." and so on (Allason-Jones, 1989: 193-8; Milne, 1995: 119; Mason, 2001: 234). Several inscriptions also refer to female individuals who were a "benefactress of..." or "heiress of..." (e.g. Rusonia Aventina, "benefactress of Lucius Ulpius Sestius", who was born in France but died in Bath; Allason-Jones, 1989: 196).

In terms of wider Roman (or Romanised) society, literary sources frequently discuss male and female roles in terms of the Roman “ideal”, that is that men are involved with politics, administration, and the military, and that women are involved with the domestic side of life; being a wife and mother, and looking after the household (Scheidel, 1995: 205-6; Hemelrijk, 2004; Revell, 2005). In reality, these idealised roles are more likely to have been adhered to by the wealthier classes (Scheidel, 1995: 207). For everyone else, these idealised roles are much less viable, and presumably both men and women would be found undertaking a wide variety of occupations. A cursory scan of ancient literary sources and modern texts discussing female occupations could lead to the belief that the majority of women not lucky enough to marry a rich man would have been sold as slaves or worked in brothels (Clark, 1981: 197-8). While this was undoubtedly the case for some women, and women would also be the most likely candidates to take care of domestic chores and rearing children, those with jobs and careers are equally likely to have been working in industry (e.g. textiles), agriculture, trade and production, amongst other things (Clarke, 1981: 197-8; Allason-Jones, 1989: 64, 70, and 80-1; Scheidel, 1995: 205-7).

Significantly higher prevalence of both craniofacial and post-cranial trauma was observed at *Eboracum* compared to the other observed towns. Craniofacial trauma was found in the form of healed nasal and maxillary fractures, and depressed cranial fractures. These types of injury are most commonly caused by interpersonal violence (e.g. being hit in the face) and accidental/intentional injury by low velocity blunt force trauma by small projectiles (e.g. slingshot). High levels of craniofacial trauma and injury, therefore, suggest an elevated level of interpersonal violence at *Eboracum* compared to other urban settlements (although injury as a result of a deliberate violent act does not imply active involvement by the recipient: Brickley and Martin, 2006: 171). Facial trauma, in particular, is most often associated with assault (Walker, 2001: 582-3; Alvi *et al.*, 2003: 103; Lee *et al.*, 2010: 194); unlike post-cranial trauma, accidental injury is less likely to occur to the head and face (Webb, 2009: 202). Accidental injury involving the skull is more likely to occur in later, industrialised societies (Miller and Jennett, 1968: 992).

Post-cranial trauma was observed in all regions of the body, and was fairly evenly distributed in terms of location prevalence. There was one exception to this: by far the most commonly affected region was the toes (9% of distal foot phalanges affected c.f. 0-2.7% prevalence in all other regions). Traumatic ankylosis is most likely to occur as a result of very localised trauma, e.g. a heavy object landing on the toe, kicking, "stubbing" injuries etc. (Lovell, 2008: 359). Ankylosis may also occur as a result of trauma where ligaments are torn (Lovell, 1997: 151).

Whatever the case, this type of trauma is likely to be accidental. Although trauma rates per post-cranial skeletal element were consistently low (with the exception of the intermediate and distal phalanges of the feet), overall frequency and crude prevalence was still significantly higher than at all other observed comparative sites. Although the location and type of each injury may provide enough evidence to determine how the injury occurred, it is often difficult to ascertain whether the cause was accidental or intentional. While cranial trauma is more likely to be deliberate, post-cranial trauma could equally be accidental or intentional. Furthermore, the same types of injury may be caused by either deliberate or accidental trauma (Lovell, 1997; Walker, 2001: 582).

Without detailed analysis of every single example, it is difficult to determine whether the post-cranial injuries observed at *Eboracum* suggest that the population was excessively violent, or just very accident prone. In all likelihood, the observed post-cranial injuries probably result from a combination of deliberate and accidental traumatic events. Patterns of injury are highly culturally specific, being likely to vary both between and within populations (Brickley and Smith, 2006: 165-6). Types of violence are also culture specific, particularly in terms of factors such as weapon choice, or even social class (Walker, 2001; Brickley and Smith, 2006: 168-70). Thus, while it is possible to infer specific causes of injury in individual cases, it is much harder to determine the cause of the pattern of trauma observed across the whole population.

Statistically, males had significantly higher prevalence of both craniofacial and post-cranial trauma than females. Sex distribution of craniofacial fracture has been found to vary greatly from study to study (both clinical and osteological), with biases towards either sex or equal distribution between the sexes (Shepherd *et al.*, 1988; Shepherd *et al.*, 1990: 77; Walker, 2001: 582; Gassner *et al.*, 2003: 53; Judd, 2004;). This suggests that distribution of craniofacial trauma between the sexes is likely to be influenced by socio-cultural factors associated with the population in question. With post-cranial fractures, frequency of the majority of fracture types was very low, and little in the way of meaningful results would be gained by trying to examine whether there are any sex differences according to fracture type.

In terms of ante-mortem craniofacial trauma, individuals buried at Driffield Terrace are more likely to have experienced trauma to the frontal, right maxilla and right parietal than individuals from any other burial location in *Eboracum*. This chapter has already discussed how facial trauma in particular is often associated with interpersonal violence, e.g. physical assault (page 299 of this study, also Walker, 2001: 582-3; Alvi *et al.*, 2003: 103; Lee *et al.*, 2010: 194). In terms of post-cranial skeletal elements, individuals from Driffield Terrace also had significantly elevated prevalence of trauma to the right ribs, second lumbar vertebra, right metacarpals and right tarsals compared to individuals from all other burial locations around *Eboracum* (page 184). Overall, post-cranial trauma is more likely to be accidental in cause, but specific causes vary according to the region of the body. For example, clinical studies suggest that rib fracture is most likely to be the result of thoracic trauma (i.e. traumatic injury to the thorax), with common causes in the modern period being traffic collisions, fall, violent physical assault and work related accident (Sırmalı *et al*., 2003: 134). In very rare cases, ribs may fracture because of increased stress to the thoracic skeleton, e.g. in the modern period, athletes such as rowers and golfers may experience stress fractures to the ribs as a result of the physical activities employed in their sport (Lord *et al.*, 1996; Christiansen and Kanstrup, 1997; Connelly and Connelly, 2004). Similar stress fractures can also be caused by coughing (De Maeseneer *et al*., 2000). Hand fractures can have numerous causes, though metacarpals are the most frequently injured hand bone in modern sports injury studies (particularly the first and fifth) (Van Onselen *et al*., 2003: 493; Aitken and Court-Brown, 2008: 1378). Sports commonly associated with fracture of the first metacarpal (at Driffield Terrace, four out of five of the right metacarpal fractures were to the first metacarpal) include rugby, football, skiing and hockey: many of the metacarpal injuries associated with these sports are thought to be related to people falling onto an outstretched hand (Aitken and Court-Brown, 2008: 1379, 1381-2). Although the significant traumatic injury locations cannot indicate specific activities that the individuals buried at Driffield Terrace were more likely to be partaking in, the injury locations themselves are interesting. Not only are the Driffield Terrace population more likely to experience head and facial injury, but post-cranial injury is also more likely to fall on the right side of the body.

All individuals with traumatic lesions from sites located on Driffield Terrace were males aged approximately 17-45 years. The combination of the male-dominated assemblage at sites on and immediately adjacent to Driffield Terrace (e.g. 129 The Mount, sites at The Mount School), plus a preponderance of decapitation burials, has been used as evidence to suggest that this area was used as a gladiator cemetery (Hunter-Mann, 2006a; 2006b; Müldner *et al.*, 2011: 9). Alternative explanations have suggested the graves are those of executed criminals, that the area was used as a military cemetery, or that these individuals are members of a religious group or cult (Hunter-Mann, 2006a; Müldner *et al.*, 2011: 9; York Archaeological Trust, 2011).

The evidence for traumatic injury provided in this study is not substantial enough to favour any particular one of these theories. Healed injuries such as those observed in this study could be related to fighting or training in gladiatorial or military combat (Kanz and Großschmitt, 2006: 215). Gladiators in other areas of the Roman Empire are known to have had good medical care to hand because of their high economic value, which could lead to the high frequency of well healed ante-mortem trauma as observed at *Eboracum* (Kanz and Großschmitt, 2006: 215). However, there is currently no known evidence for a gladiatorial school or arena at *Eboracum*. Even if gladiators were present in the town, it is unknown whether their level of medical care would match that provided elsewhere in the Empire.

Although Roman military installations are likely to have had their own hospitals, the evidence for military medical care in the north of Roman Britain is limited to a few basic medical instruments found at places such as Corbridge, South Shields and Carlisle (Allason-Jones, 1999b: 135 and 141). Even when found in association with structures, it is difficult to ascertain whether these are formal hospital buildings (Allason-Jones, 1999: 135). Written evidence (e.g. Hippocrates I: 36) does suggest that Greco-Roman medicine was adopted by the army in Britain during this time, for example, using metal levers to reduce fractures (Jackson, 2000; Baker, 2000; Redfern, 2010: 463-4), however, the extent to which these would be used may have varied between sites and practitioners. While it is likely that some measure of medical care was provided at least for soldiers residing at *Eboracum*, the paucity of evidence means it is impossible to ascertain whether the level of military healthcare could lead to the high frequency of well healed ante-mortem trauma observed in this study. In order to explore these possibilities further, an investigation into the distribution and types of trauma (both ante and peri-mortem) would be required. Furthermore, this should be related to the types of weaponry and protective equipment available to these groups.

There is a very high frequency of decapitation burials from sites located on Driffield Terrace. Although the overall crude prevalence is not significantly elevated statistically, CPR for *Eboracum* is at the very highest point in the expected range (6.62%, Chapter 4: page 193). High rates of decapitation may be considered unusual at sites such as *Eboracum*: recent work by Pitts and Griffin (2012: 270-1) strongly suggests that higher prevalence of decapitation is more closely associated with non-urban sites. However, at *Eboracum*, all except three of the decapitated burials are from sites on or immediately adjacent to Driffield Terrace. Of the three exceptions, two are from the Moss Street Depot site (YMD03, approximately 500m to the north east of Driffield Terrace, on the other side of the south west road out of *Eboracum*) and one is from Blue Bridge Lane at Fishergate (site YBB & YFH 00-04, almost 1.5km to the east of Driffield Terrace). All three of these burials are also adult males. Furthermore, isotopic analysis of a sample of individuals from Driffield Terrace shows that decapitated males from this cemetery have a significantly more diverse range of geographical childhood origins than other individuals buried in and around *Eboracum* with the usual, expected burial rites (although geographical origin does not have a direct relationship or association with decapitation: Montgomery *et al.*, 2011; Müldner *et al.*, 2011: 87-8).

In addition to the high levels of healed ante-mortem trauma and decapitation burials, the majority of other peri-mortem trauma (both blade injury and blunt force) was also found in skeletal remains from around the Driffield Terrace area. Thus, 11 out of 13 individuals with other peri-mortem blade injuries were buried at or nearby Driffield Terrace. The remaining two individuals (both adult males) were found at Moss Street Depot (site YMD014) and at the Yorkshire Museum (site report 0610, approximately 1.5km to the north east of Driffield Terrace). Similarly, seven out of eight individuals with peri-mortem blunt force trauma were buried in or around Driffield Terrace, with the other (older adult female) individual located at the 41 Piccadilly site (YORYM 1998.15), approximately 1.5km to the east. Therefore, if peri-mortem trauma CPR's (blade injury, blunt force and decapitation) are calculated for *Eboracum* with burials from around the Driffield Terrace area removed, CPR for all three peri-mortem trauma types falls to below 0.5%. Elevated prevalence of peri-mortem trauma at *Eboracum*, therefore, is largely due to affected individuals in the cemetery area at and immediately around Driffield Terrace.

For further interpretations regarding the male dominated, decapitated, traumatic assemblage from Driffield Terrace, more in-depth study is required. Examination of the assemblage by Montgomery *et al.* (2011) has suggested that the group are unlikely to be "common criminals", because of the high-status burial location on the main road. The unusual combination of preferred burial location and use of a burial rite usually reserved for social outcasts only serves to fuel speculation (Montgomery *et al.*, 2011: 168). The impending publication of the site by York Archaeological Trust will no doubt seek to elucidate the most likely theory. What the present study can confirm is that this group of individuals are likely to represent a male-dominated group, such as a burial club, social, occupational or community group, with a predisposition towards physical, traumatic injury (accidental or otherwise), diverse geographical origin and differential burial rites. This may include, but is not limited to a military group or gladiatorial school. The presence of individuals with such high levels of trauma undoubtedly had a significant impact on rates of trauma for the town as a whole, and indicates that this group were significantly more prone to certain types of physical injury than individuals from all other burial locations.

Crude prevalence of non-specific infection at *Eboracum* was high, the third highest rate across all observed towns (and at the top end of the overall non-specific prevalence range shown in Figure 4.33, page 231). Bone lesions associated with non-specific infections can be related to both specific infectious disease such as tuberculosis and syphilis, or miscellaneous conditions and infection or inflammation of adjacent soft tissues (Goodman *et al.*, 1988: 178; Grauer, 1993: 204; Roberts and Cox, 2003: 124). In order to calculate crude prevalence for this pathological category, data for periosteal new bone formation, osteitis, osteomyelitis and miscellaneous evidence of non-specific infection was collated. As the same data was combined for all comparative sites by this, the observed high prevalence at *Eboracum* is unlikely to be affected by data omission and subsequent under-representation at the comparative sites.

In terms of specific infection, both true and crude prevalence of tuberculosis at *Eboracum* was low, and skeletal involvement is limited to the lower lumbar/first sacral vertebra and the pelvis. Skeletal manifestations of tuberculosis are usually associated with the secondary stages of the disease; the primary stage of infection only affects the soft tissues, with the secondary stage occurring as a result of reactivation or reinfection (Aufderheide and Rodríguez-Martin, 1998: 118-20; Roberts and Buikstra, 2003: 88). Gastro-intestinal tuberculosis (caused by *Mycobacterium bovis*) is usually contracted as a result of consuming infected animal products, e.g. meat and milk. Consumption of infected produce transmits the infection transmitted to the human gut: therefore the disease is likely to manifest skeletally on the internal surface of the pelvis (Roberts and Buikstra, 2003: 5 and 98; Roberts and Cox, 2003: 119). Involvement of the vertebrae may be an extension of an infection initiating in the pelvic region; the spine is the skeletal region most commonly involved in skeletal tuberculosis (Aufderheide and Rodríguez-Martin, 1998: 134). Bovine tuberculosis can occur commonly in children (as a result of milk consumption), so it is possible that both these individuals originally contracted the infection during childhood, becoming reinfected during later life (Roberts and Buikstra, 2003: 77; Holst, 2008: 6).

Prevalence of maxillary sinusitis is generally thought to be very low throughout British prehistory, with prevalence only starting to increase during the Iron Age and Roman period (Roberts and Lewis, 2002: 183; Roberts and Cox, 2003: 112; Bernofsky, 2010: 39). This increase in prevalence is likely to reflect changes in the lifestyle of the population (increased population density and human contact, increased urbanisation etc.) and increase in indoor pollution (Bernofsky, 2010: 22-3). Having said this, the observed rate of maxillary sinusitis can also be affected by the completeness and/or fragmentation of the skeletal sample. If complete skulls from sites with lower prevalence (observed in this study, such as York and Dorchester) were examined using an endoscope, more cases of this pathological condition may be observed osteologically.

Higher prevalence of infectious disease (whether specific or non-specific) is often attributed to factors such as high or increased population size and density, transition to permanent housing and/or sedentary lifestyle, increased interregional mobility and contact, poor sanitation, and insufficient nutritional uptake (Wood *et al.*, 1992: 358; Grauer, 1993: 204; Manchester, 1995: 10; Roberts, 2000: 147; Peck, 2009: 147). When considering the development of *Eboracum* and changes in settlement type instigated by the arrival of the Romans in the area, it is highly likely that all these factors were at play, and would have contributed to disease levels and susceptibility of the population to infection. Peck's (2009: 114) study shows that the Romano-British population from Trentholme Drive was five times more likely to develop periostitis than the Iron Age population from East Yorkshire. Furthermore, the results of this study indicate that the population of *Eboracum* was substantially larger than previously thought, particularly in the later period of occupation. The arrival of the Roman army, establishment of the fortress and eventual development of the town meant that for the first time, large numbers of people were living in much closer quarters. Higher population density would then serve to promote the transmission of infection.

The picture regarding town sanitation in *Eboracum* is rather mixed. On the one hand, the fortress buildings appear to be well maintained, with good drainage, a clean water supply, and regular refurbishment (Addyman, 1989: 246; Ottaway, 2004: 67-75 and 94). The construction of a large stone sewer at Church Street strongly indicates measures were being taken to remove human waste from living areas (Buckland, 1974; Ottaway, 2004: 44-6). The presence of several public and military bath houses (examples of public baths have been excavated at 1-9 Micklegate, Toft Green, Bishophill, the Old Station and Fetter Lane, military bath houses are located within the fortress: York Archaeological Trust, 1973; Ottaway, 2004: 42 and 92; Robinson, 2012, pers. comm.) indicates that that provisions were also made for public bathing and personal cleanliness. However, the regularity with which such public facilities would be cleaned is debateable: bath houses may, therefore, have aided in the transmission of bacteria and infection rather than facilitating good personal hygiene (Allason-Jones, 1989: 83).

On the other hand, environmental evidence from several sites immediately adjacent to the River Ouse suggests that these areas were used as dumping grounds for general waste in the earlier periods of occupation, to the extent that these areas would have posed a health hazard (Addyman, 1989: 250). Furthermore, faunal evidence suggests that vermin such as rats and mice were a common problem in the town from the second century (Addyman, 1989: 250; Ottaway, 2004: 108). Evidence for the presence of vermin and dumping of human and general waste has also been found at the General Accident site: these activities are likely to date to the second century, but it is unclear whether this would have been a typical phenomenon throughout *Eboracum* at this time, or whether this is merely an example of localised rubbish deposition (York Archaeological Trust, 1984; Ottaway, 2004: 108-9). Analysis of waste deposits from the Church Street sewer has also indicated the presence of human gut parasites, and mid second century drain and ditch fills from Tanner Row and Rougier Street have contained the eggs of two species of intestinal parasitic worms (*Trichuris* and *Ascaris*, though both species may be carried by animals and do not prove the sewer contained human excrement: Buckland, 1974; Wilson and Rackham, 1976: 32; Dobney *et al.*, 1999: 20). As discussed in Chapter 2, increased rubbish dumping and presence of “dark earth” from the fourth century indicates that standards of sanitation and hygiene in the town are likely to have slipped in the later period, which is likely to have increased the populations' susceptibility to infection and ill health.

Another factor that may have contributed to disease load and lowered the population's resistance to infection is insufficient nutritional uptake. This has already been discussed in previous sections of this chapter: the population of Roman York are unlikely to have been consuming sufficient quantities of fruit and vegetables, leading to deficiency in certain vitamins and nutrients. However, not only would immunity to infection be lowered by insufficient diet, but that the presence of intestinal parasites and worms would exacerbate the problem (also potentially expelling any quantities of vitamins and nutrients that have been consumed before they can be absorbed by the body). Individuals that harbour parasites such as those found at *Eboracum* (*Trichuris*, whipworm, and *Ascaris*, roundworm) are more likely to suffer from symptoms such as diarrhoea and vomiting, particularly during moderate or severe infestations. Not only do these symptoms serve to increase nutrient loss, but they are also likely to decrease food intake (Stephenson *et al.*, 2000: S78). Both species of intestinal parasite are also highly likely to re-infect their host if no treatment is administered and sanitation remains poor, so the effects of infestation are likely to be accumulative (Stephenson *et al.*, 2000: S76). It is easy to see how factors that cause lowered immunity to infection can aggravate each other and worsen the problem.

Of course, we must also consider that the observed osteological evidence of infection (whether specific or non-specific) may actually be indicative of higher immunity. The "osteological paradox" suggests that individuals exhibiting healed pathological lesions have lower risk of frailty and death: these individuals must be in superior health as they were able to survive infection long enough to manifest a healed lesion (Wood *et al.*, 1992: 353). Weaker individuals are more likely to die shortly after contracting infection, before a skeletal response or while infective lesions are active (Wood *et al.*, 1992: 353). This theory therefore suggests that populations exhibiting high frequency of healed lesions are more likely to be in a good state of health, and have good ability withstand stressors (Grauer, 1993: 204-5). If this is correct, observed high prevalence of non-specific infective lesions at

Eboracum may suggest the population were healthy and had relatively low frailty. However, the fact that individuals from *Eboracum* were experiencing the need for an immune response (in addition to the aforementioned archaeological evidence regarding town sanitation; pages 307-8) supports the theory that the town of *Eboracum* was a rather unhygienic place.

Rates of infection in the *Eboracum* population also show significant male bias. This is especially interesting when also taking into consideration Peck's (2009: 148) finding that Romano-British males from Trentholme Drive were at much higher risk of periostitis than Iron Age males from East Yorkshire, whereas females from the same populations were at approximately the same risk. Frequency of non-specific infection was also higher in males from eight out of nine observed comparative towns. Although these rates could not be tested statistically to see if the observed bias was significant (partly due to time constraints upon the present study, but also because of insufficient raw comparative data), male biased infection rates do appear to be repeated across Romano-British urban populations. Generally, male morbidity for infection is greater, although other factors such as increased female immunity or males being exposed to more infectious agents may also be contributing factors (Ortner, 1998: 80-6). However, ratios are also likely to be affected by time period, geographical region, socio-cultural and other factors, meaning that the precise cause of the observed sex bias in non-specific infection prevalence is likely to be complex and multi-aetiological.

As previously stated, although porotic hyperostosis and cribra orbitalia have frequently been associated with iron deficiency anaemia and Vitamin B deficiency, macroscopic observation of these lesions is best used as being evidence of general stress (Steckel *et al.*, 2006: 12-13). Results show that prevalence of cribra orbitalia appears to vary substantially between all observed populations, with rates being at the lower end of the expected range at *Eboracum*. Potentially, this could indicate that individuals in this population were at low risk of infection/deficiency/anaemia during childhood, or in line with the osteological paradox theory, experienced elevated immunity (Wood *et al.*, 1992). This is not altogether in keeping with the aforementioned evidence for sanitation in

Eboracum (page 307-8), and may again be indicative that members of this population may have been likely to grow up elsewhere, and migrate to York during/after childhood (for further discussion of this, see pages 312-3). Furthermore, how does low prevalence of cribra orbitalia fit with higher observed prevalence of enamel hypoplasia? Although there is no direct correlation between the development and presence of enamel hypoplasia and cribra orbitalia, a number of studies have suggested that children undergoing nutritional and/or environmental stress could potentially be susceptible to development of both lesions (Stuart Macadam, 1985; Zink, 1999; Obertova and Thurzo, 2008). Conversely, and more in line with findings from *Eboracum*, other studies have demonstrated an inverse relationship between cribra and enamel hypoplasia (e.g. Mittler *et al*., 1992; Gowland and Garnsey, 2010: 144); it is clear that the precise relationship between these two conditions requires further study.

Prevalence of porotic hyperostosis follows a different pattern, being consistently low at comparative sites, but with anomalously high prevalence at *Eboracum*. Observed rates of porotic hyperostosis at *Eboracum* could more closely approximate genuine prevalence of the condition in the living population, with heavily remodelled lesions perhaps being overlooked osteologically. Chapter 4 demonstrates how remodelled lesions associated with porotic hyperostosis may be difficult to observe macroscopically. This may also be evident when comparing rates of CPR of cribra orbitalia and porotic hyperostosis in the same population: frequency and prevalence rates of these conditions in *Eboracum* are very similar, where at all other comparative sites, porotic hyperostosis rates are much lower. This may be a reflection of the fact that cribra orbitalia lesions, even when substantially remodelled, are easy to recognise osteologically. The somewhat more subtle appearance of remodelled porotic hyperostosis lesions can render them easy to miss. Furthermore, any variation in the recording strategies employed by osteologists when observing these lesions may lead to differential diagnosis of those that are more subtle in appearance (Jacobi and Danforth, 2002).

Alternatively, some of the heavily remodelled lesions recorded as porotic hyperostosis in the present study may in fact be evidence of healed scalp infection (Ortner, 2003: 102; Walker *et al*., 2009: 109). Chronic scalp infection is often cited as an alternative diagnosis to porotic hyperostosis (Ortner, 2003: 102; Walker *et al*., 2009: 109). The presence of scalp infection in the population of Roman York would also fit with the evidence for relatively high proportions of non-specific infection observed in this study. Unfortunately, it is extremely difficult to distinguish between true porotic hyperostosis and infectious scalp lesions macroscopically, particularly when the lesions are well healed. Thus, there is potential for future microscopic study of the examples from Roman York (e.g. after Dominguez-Rodrigo *et al*., 2001), which may be able to provide a more conclusive diagnosis.

Whatever the case, in the present study, significantly lower prevalence of porotic hyperostosis in the comparative samples therefore likely pertains to observational difficulty or differential diagnosis within archaeological samples. Cribra orbitalia prevalence at *Eboracum* is likely to be genuine, and hence, low for the period. Considering that frequency and crude prevalence of cribra orbitalia and porotic hyperostosis is very similar at *Eboracum* (approximate CPR of 5-6%), these figures may in fact reflect relatively low overall prevalence for both conditions. Other general indicators of stress – namely enamel hypoplasia and non-specific infection – were found to affect higher proportions of the population (approximately 53% and 11% of the population respectively). When considering all four pathological conditions together as general stress indicators, the observed pattern is rather mixed. However, the most commonly found stress indicator, enamel hypoplasia, is more likely to be related to stress occurring at an early age. Therefore a tentative explanation for the observed results may indicate that the population was more likely to be subject to dietary (and other) stressors during childhood, with lower/moderate exposure to stressors during adolescence and adulthood. The latter theory is substantiated by recent research by Pitts and Griffin (2012), whose study of late Romano-British cemetery sites found that health and nutrition was significantly better at urban and nucleated sites when compared to their rural counterparts. Patterns of health were found to be strongly associated with site type (i.e. dependant on whether the site was urban, nucleated or rural) as well as road connectivity and diet (Pitts and Griffin, 2012: 260 and 272). This may indicate that the health status and diet at *Eboracum* was better than at nearby rural sites. Further study is required to verify this theory.

Finally, consideration should be given to how the above pathological evidence may relate to migration. Development of pathological lesions such as enamel hypoplasia and cribra orbitalia, are related to nutritional intake during childhood, and several conditions may have a genetic (e.g. neoplastic disease, joint disease) aetiology (Lanphear, 1990; Ortner, 2003: 503-4, 562; Walker *et al*., 2009). Therefore, several of the pathological conditions observed at York may not necessarily relate directly to York's environment. This study has already demonstrated that, like many urban populations in Roman Britain, a proportion of the population of Roman York are migrants (e.g. the Ivory Bangle Lady, individuals from Driffield Terrace etc; Eckardt, 2010; Leach *et al*., 2010; Müldner *et al*., 2011). Consequently, prevalence rates of illnesses and conditions at York that relate to childhood are likely to have been influenced to a certainy degree by diet, lifestyle and environment etc in the parent populations, i.e. elsewhere. This scenario has previously been suggested as a factor affecting rates of conditions such as enamel hypoplasia and cribra orbitalia in Roman London (Gowland and Redfern, 2010).

These factors are difficult to discuss in terms of specific locations and populations (migrants to Roman York have been shown to have originated in a wide variety of locations, ranging from other parts of Yorkshire through to the farther reaches of the Roman Empire; Leach *et al*., 2010; Müldner *et al*., 2011). Furthermore, it is impossible to quantify, based on the current evidence, the exact number or proportion of the York populace that grew up in a different location, at what time during life they may have moved, and indeed, whether people would have been likely to move from one location (e.g. place of birth) to a second (e.g. York) and remain there, whether they would have been travelling to a variety of places throughout their lifetime, or whether frequency of travel/settling was at any level inbetween these two extremes. The population of York is highly likely to have contained a substantial proportion of migrants throughout the entire period of Roman occupation, in terms of both members of the military and civilian populations (Leach *et al*., 2009).

The military population particularly are likely to have travelled significantly: the founders of *Eboracum*, Ninth Legion, for example, may have originated in Gaul, and various documents and inscriptions indicate that they were stationed at a variety of places in Croatia, Italy, Spain, and Africa prior to their deployment to Britain in 43 A. D. (Keppie, 2000b: 201-2). A legion's time would not necessarily be spent stationed in one location within a country or province either: The amount of time spent in these locations would vary depending on political change and where the services of the legion were required (e.g. the Ninth legion is thought to have been based in Spain for approximately 11 years, from 30-19B. C., but only three years in Africa from 20-23 A. D.; Keppie, 2000b: 201-2). Furthermore, a legion may not stay in one exact location even when stationed: parts of the Sixth legion are known to have spent time working on Hadrien's Wall even when they were officially based at York (Ottaway, 2004: 102). These examples serve to illustrate that as well as a soldiers' geographical origins, deployment locations are also likely to have had a bearing on health, even if length of stay in these locations was relatively short.

The aforementioned factors make it extremely difficult to speculate the extent to which pathological conditions observed in the population from York would have been influenced by individuals previously being members of different populations. Furthermore, the transient nature of military life is also likely to have had a bearing on health status. Whatever the case, when examining health status in archaeological populations, both short and long term migration, population movement and transience should at least be considered as having an influence, even if that influence cannot be measured.

In terms of *Eboracum*, general patterns of health do conform to the trends observed in populations from all towns. It should be noted that as with many of the findings in this study, patterns of health at *Eboracum* are more likely to relate to the later period of occupation, because of the paucity of skeletal material relating to the earlier period. Furthermore, migration and population movement is also likely to have influenced health status in this population. Many of the observed pathological conditions with elevated values at *Eboracum* may be the result of poor comparative data, osteological rarity of a condition, or a combination of complex causal factors that are yet to be understood both clinically and osteologically. Generally, adult male individuals from the town are more likely to be physically active, partaking in activities that place stress on the left shoulder joint or increase torsional rotation of the spine. Probably the most stand out pathological results relate to trauma, with individuals from *Eboracum* more likely to experience traumatic injury than individuals from the comparative populations.

5.5. Summary

The military presence at *Eboracum* undoubtedly had a significant effect on the composition of the town's populace. This finding is unlikely to come as a surprise: even minimal occupation of the fortress by the military is likely to have had a considerable impact on the nature of the settlement. The palaeodemographic results of this project are largely tentative, broad and general in scope, principally because of the methods and materials available. However, this study is the first real attempt at comprehensive analysis of the structure and composition of the population of *Eboracum*. Although some of the results may not be particularly surprising, this is the first time that there has been systematic analysis to provide demographic evidence to base any given theories upon.

As with the palaeodemographic findings, results pertaining to diet in *Eboracum* are broad and general in scope. Dental pathological data gleaned from this study corroborates other lines of evidence to suggest that dietary staples in *Eboracum* are likely to have been foodstuffs such as beef and bread. These would have been supplemented by a variety of other foods such as dairy products, fish and occasional imported foods such as dried figs and olives. Dietary range and breadth appears broadly to correlate with expected dietary patterns observed at other Romano-British urban/military sites (particularly in the north of England). One exception to this is that far fewer cariogenic foodstuffs appear to have been consumed at *Eboracum* than at other Romano-British towns. Unfortunately it is not currently possible to ascertain any differences or similarities between military and civilian diet. This problem cannot be resolved until a reliable way of distinguishing military from civilian burials can be found.

On the whole, the health status of the population of *Eboracum* is comparable to the health status observed at similar, contemporary urban sites. General levels of stress within the population appear to be low, though levels of activity related mechanical stress and non-specific infection are higher. Higher levels of traumatic injury (particularly pertaining to the cranium) are predominantly found in an unusual group of male burials located around the Driffield Terrace area of the main cemetery on the south west road heading out of *Eboracum*. Therefore, trauma prevalence in the rest of the population falls within the expected (low) prevalence range.

Chapter 6: Conclusion

This study has attempted to provide a broad reconstruction of the population of *Eboracum*. Comprehensive analysis of the human skeletal assemblage from this Roman town has provided unique information relating to a population for which little other direct evidence survives. Collation and analysis of osteological data from 94 sites (see Appendix 1) has facilitated tentative reconstruction of the size and composition of the population, as well as reconstruction of broad patterns of diet and health. In summary, this study has established the following:

- The demographic composition of the population was heavily influenced by the presence of the military
- The population is likely to have been larger than originally estimated, at least in the mid/later period of occupation (approximately c.150-350 A. D.)
- The area around the south west approach road was markedly preferable as a burial location
- A high proportion of this population's diet is likely to have comprised of foods rich in fat and carbohydrate
- Diet is also likely to have comprised relatively low proportions of cariogenic foods and foods rich in vitamins and calcium
- Pathological results suggest that the population was physically active and more prone to traumatic injury than populations from contemporary urban sites, with males more likely to take part in activities that place strain on the rotator cuff or increase torsional rotation of the spine
- A group of males buried in the location now known as Driffield Terrace were significantly more prone to traumatic injury in the cranium and several locations in the post-cranial skeleton than the rest of the population, and, indeed, populations from other urban Romano-British sites. This group is highly likely to represent a distinctive male-dominated, traumatic injury-prone community residing within the town

- Males were more prone to non-specific infection, and this pattern appeared to be repeated across most contemporary towns observed in this study
- Typically, populations from Romano-British urban sites are likely to have higher and more variable rates of degenerative joint disease and Schmorl’s nodes, moderate levels and range of conditions such as post-cranial trauma, osteochondritis dissecans, non-specific infection, and cribra orbitalia, and low levels and narrow ranges of all other pathological conditions

This research is significant in that it is the first (and much needed) attempt to pull together the entire body of osteological data for a Romano-British town. Although comparative data were available from similar contemporary urban sites, these were typically from discrete cemeteries, or several cemetery areas combined by this author. This study has shown that by drawing together data from multiple cemetery sites, it is possible to establish a town-wide picture of a settlement population, based on a larger sample of individuals, rather than concentrating on individual case studies or smaller burial groups. Collection of data from a variety of burial locations increases the likelihood that we are viewing data from individuals from all sections of society, even if it is not possible wholly to distinguish these groups based on the available information.

Furthermore, this study has confirmed the assumption that the military component of the population had an enormous influence on the composition of the population, but has also established that male bias within the population was not as high as previously suggested. This fits with the findings of Peck’s (2009) re-appraisal of the Trentholme Drive assemblage, and serves to highlight the point that where possible and appropriate, skeletal assemblages should be re-analysed periodically using new osteological methods, techniques and standards. The highly skewed Trentholme Drive sex ratio of approximately four males for every one female (Wenham, 1968: 147) is often quoted in literature such as osteological reports and peer reviewed papers, with the assemblage frequently cited as a marked example of an extremely sex-biased population (Jones, 1984; Morris, 1992: 83; Davison, 2000; Crowe, 2001: 149; Wacher, 2002: 824; Müldner, 2005:

90). In the future, researchers should cease to rely on the Wenham (1968: 147) sex ratios, as this study clearly shows that the original estimations are incorrect.

6.1. Limitations of the Study

One obvious limitation of this type of study is that the results are very broad ranging, and may only be applied generally to the population. However, this is largely a product of the given time frame in which this study took place. More in-depth study across all observed facets of such a large assemblage would take far more time than was available for this doctoral thesis. The broad ranging character of this study has also served to highlight several interesting aspects of the *Eboracum* assemblage that could be focussed on in more depth in future work.

Additional limitations relate to the skeletal material available for study. Paucity of material dating to the earlier period of occupation means that many of the results of this study are only applicable to the mid/later period. Unfortunately, as this is the result of many of the burials likely to relate to the earlier period, e.g. cremation burials, being lost, this is not a problem that can be addressed unless more burials of this date are discovered. Furthermore, dating of many of the burials is rather vague. This problem can only be remedied by establishing a more precise dating sequence and burial chronology for a larger proportion of the assemblage.

Moreover, one of the original intentions of the study, comparison of the military and civilian sections of society, was not possible. This again, was due to limitations within the available evidence. While a small number of tombstones do survive that describe their owners as belonging to one of these groups, the number is too small to facilitate meaningful comparison and the tombstones are often reused (e.g. in later masonry) or found without the original associated burial. Without survival of evidence allowing identification of individuals as specifically belonging to military or civilian sections of society, osteological comparison of these two groups is impossible.

One last constraint on this study is that the skeletal sample was not quite as comprehensive as originally intended. Obviously new burials may be found at any time, and a number of burials were discovered at a point where it was too late to incorporate the new data into this study. For example, the unearthing of approximately 112 Roman individuals from the cemetery at Hungate by York Archaeological Trust in the summer of 2012 (Connelly, Pers. comm.) had the potential to contribute significantly to the data already collated for this study, but unfortunately the discovery was made at a point when the majority of data analysis was already complete. As well as this new information, the situation regarding data for the Trentholme Drive assemblage made integration of the assemblage into this study very problematic. Fortunately, recent work by Joshua Peck meant that at least the demographic component of the data was compatible with this study. It is recommended that where possible, all re-numbered individuals from the Trentholme Drive assemblage are also assigned their original skeleton number from the excavation. It is also recommended that the whole collection is comprehensively reanalysed according to current recommended osteological standards and methods of recording, and that some effort to re-unite the material at the Natural History Museum with that kept at the Yorkshire Museum is made.

6.2. Future Potential

The results of this study suggest a plethora of areas for future development and research. As well as potential work integrating new burial data (and more compatible data from Trentholme Drive), a number of further in-depth studies could be conducted using the existing osteological evidence and burial data. Demographically, it would be useful to conduct a thorough investigation of how the observed population statistics relate to site type. Observation of sex ratios from *Eboracum* and the comparative sites in this study indicates a difference between sites that may be related to levels of military activity and influence. Furthermore, this study has not had the scope to investigate fertility and survivorship. Average life expectancy is heavily dependent on rates of fertility (Gowland, 2007: 156), with low mean age at death often equated with high fertility rates. This relationship could definitely be investigated with regards to the population of *Eboracum*.

Further work could also be conducted in regards to the cemetery areas. Although this study has considered the cemeteries as solely serving the town of *Eboracum*, it is possible that in reality, these cemeteries were also serving the rural hinterland. This theory has previously been proposed in regards to the cemetery at Poundbury (Williams, 1999: 101). If this is the case at *Eboracum*, could contributions of dead from surrounding rural communities account for the larger population size estimation put forward by this study? In light of this question, it would also be useful to establish a more precise geographical area that would fall under the influence/jurisdiction of *Eboracum*, and perhaps how far this incorporated lands considered to be part of the *Territorium*. It is unclear from this study just how possible this type of analysis would be, but investigation into producing geographical models of the area, perhaps based on principles such as Thiessen Polygons (Boots, 1980), may be the way forward. Theissen Polygons (also known as Voronoi Polygons) are spatial modelling tools that can be used to estimate the area of hinterland utilised by a settlement (Boots, 1980). Application of this method has previously been attempted at several Romano-British urban sites, notably in Hodder and Hassall's (1971) study of non-random spacing of Romano-British walled towns.

There is certainly scope for more research into health patterns in the population of *Eboracum*. Of particular interest is the prevalence of non-specific infection at *Eboracum*, which should be examined by sex (in view of the significantly elevated prevalence in males), age, and also the patterns of remodelled and unremodelled lesions across these groupings. This analysis would allow insight into patterns of mortality and morbidity within an urban community.

Future findings and their interpretations should also be considered with regards to the osteological paradox (page 308 of this study, also Wood *et al.*, 1992). A similar study has already been conducted using a medieval skeletal assemblage from St. Helen-on-the-Walls in York (Grauer, 1993), and Peck's 2009 study has already examined differential prevalence of non-specific infective lesions in Iron

Age Arras burials from East Yorkshire and his sample of individuals from Trentholme Drive. Therefore, in-depth analysis of the Roman assemblage from York could also facilitate comparison of findings for the town over time, building a developmental picture of how health in the population has changed over the centuries.

Another potential area of study concerns the unusual burials from Driffield Terrace. This study has shown that there are clear differences between this group and the rest of the observed population, notably in terms of sex composition, trauma rates, burial rite and even geographical origin. An in-depth comparative study between these burials and the rest of the population could examine these differences further, as well as investigating the potential for further differences that this broad study may have failed to observe. Clearly this distinct group of individuals provide the most solid available evidence for social differentiation within the population of *Eboracum*. The forthcoming publication on the site by York Archaeological Trust is likely to explore some of these themes, but not conduct an absolute comparison with the rest of the population.

6.3. Final Remarks: The Importance of the People of Roman York

Ultimately, the arrival of the Ninth Legion in the Vale of York in 71 A. D. not only gave rise to a brand new urban settlement but also led to the development of a cosmopolitan population comprising a mixture of local Britons and “Romanised” immigrants. Although evidence pertaining to the earliest form of the population is somewhat scant, it is apparent that by the mid second century, the town and its people had developed considerably into a typical Romano-British urban settlement with a significant military component. By the third century, the importance of the town in terms of both Roman Britain and the wider Roman Empire is signified by the granting of *colonia* status and occupation by a number of Roman Emperors. Undoubtedly, and as this study shows, this mixture of social and cultural influences had huge implications for the character of the town and composition of the population.

What makes *Eboracum* unique is that it is the only known settlement of this type or status in the north of Britain. Most settlements to the north of *Eboracum* (and in the north of Britain during this period) are largely military in purpose, or are considerably less urbanised. To the south, the nearest comparative settlements (at Chester and Lincoln) do not currently yield sizeable, published burial assemblages. By examining the population of *Eboracum*, we gain information about people from a distinctive settlement, both a liminal frontier town and centre of administration, with both military and civilian, and native and migrant components. This study thus provides a valuable insight into the lives of an exceptional population from an important urban centre.

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McIntyre, L. 2011d. Healed double fracture to the left ulna. NHM 152 Wenham 95, Trentholme Drive. Taken with permission of the Yorkshire Museum.

McIntyre, L. 2011e. *Healed fracture to the left tibia. SK 2333, Shearsmith's building, Lion and Lamb car park, Blossom Street*. Taken with permission of York Archaeological Trust.

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McIntyre, L. 2011h. *Posterior aspect, fifth cervical vertebra. Decapitation. SK 9, The Mount School, Driffield Terrace*. Taken with permission of York Archaeological Trust.

McIntyre, L. 2011i. *Osteochondritis dissecans, superior aspect of the medial condyle, right tibia. From section T2A-5, Trentholme Drive*. Taken with permission of the Yorkshire Museum.

McIntyre, L. 2011j. *Anterior view, joint disease in the right hip. This joint has become almost completely immobile. SK 10, Bar Convent*. Taken with permission of the Yorkshire Museum.

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Appendix 1: Site Gazetteer

The number of burials given in the table below is the number known to have osteological data, either in existing reports or examined by this author. Sites marked with a * are located within the confines of the Roman settlement. Sites marked with a ^ have NGR's that have been changed from the original report NGR, in order to more accurately reflect the location of the excavation.

	Site	Record ID	No. Inhum.	No. Crem.	No. Disartic. contexts	NGR	Reference
1.	129 Holgate Road, York	YATGAZ 1980.31	1	0	0	SE 5904 5121	York Archaeological Trust. 1980. *129; Holgate Road, York*. Site 1980.31, archive notes.
2.	129 The Mount, York	YORAT 2006:25, SYO 1006	2	0	0	SE 5933 5092	Evans, D. 2007. *129 The Mount, York. A Report on an Archaeological Watching Brief*. . Unpublished report no. 2007/02 for York Archaeological Trust. Also Tucker, K. 2005. Unpublished osteological notes.
3.	1-3 Driffield Terrace, York	YORYM 2004.354, SYO 556	56	19	95	SE 5932 5100	Ottaway, P. 2005. *1-3 Driffield Terrace, York. Assessment Report on an Archaeological Excavation*. Unpublished report no. 2005/27 for York Archaeological Trust. Also Tucker, K. 2005. Unpublished osteological notes.

	Site	**Record ID**	**No. Inhum.**	**No. Crem.**	**No. Disartic. contexts**	**NGR**	**Reference**
4.	14-18 Malborough Grove, York	EYO 390, York Council 206	3	0	5	SE 6063 5097	Field Archaeology Specialists. 2000. *Archaeological Evaluation. 14-18 Marlborough Grove, York, North Yorkshire*. Unpublished report.
5.	14-20 Blossom Street, Fulford, York	1991/11, EHNMR 659465, SYO 226, EYO 16	0	0	1	SE 596 514	York Archaeological Trust. 1991. *Report on an Archaeological Evaluation at 14-20 Blossom Street, York*. Unpublished field report.
6.	147 Newington Terrace, (147 Mount Vale), York	YORYM 1975.30, 635515, EHNMR-635515	3	0	0	SE 591 507	This study.
7.	16-22 Coppergate, York*	YATGAZ 1976-81.7	7	0	21	SE 6044 5168	This study.
8.	18 Bootham Terrace, York	OSA06WB19	2	0	1	SE 5975 5260	Robinson, T. 2006. *18 Bootham Terrace, York; Report on an Archaeological Watching Brief. OSA Report No. OSA06WB19*. Unpublished report.

	Site	**Record ID**	**No. Inhum.**	**No. Crem.**	**No. Disartic. contexts**	**NGR**	**Reference**
9.	18-20 St. Maurice's Road, York	OSA05EV04	1	0	0	SE 6067 5221	Stirk, D. 2005. *18-20 St. Maurice's Road, York; Report on an Archaeological Evaluation. OSA Report No. OSA05EV04*. Unpublished report.
10.	2-4 Driffield Terrace, York	YDT03, SYO 475, EYO 268	3	3	0	SE 5932 5100	Field Archaeology Specialists. 2003b. *2-4 Driffield Terrace, The Mount, York; Archaeological Evaluation (Site YDT03)*. Unpublished report.
11.	26-28 Marygate, York	1992.11	3	0	0	SE 5985 5231	York Archaeological Trust. 1992. *Report on excavations at 26-28 Marygate, York*. Unpublished report.
12.	3, Clifton, York	YATGAZ 1994.1780 YYM	0	0	1	SE 5974 5256	This study.
13.	33-34 St. Mary's, York^	OSA08WB26	3	0	0	SE 59868 52341	McCluskey, B. 2010. *33-34 St. Mary's, York; Report on an Archaeological Watching Brief*. *OSA Report No. OSA08WB26*. Unpublished report.
14.	41 Piccadilly, York	YORYM 1998.15	8	2	0	SE 6072 5143	MAP Archaeological Consultancy. 1998. *Archaeological Excavations - 41 Piccadilly, York; Assessment Report*. Unpublished report.

	Site	**Record ID**	**No. Inhum.**	**No. Crem.**	**No. Disartic. contexts**	**NGR**	**Reference**
15.	6 Driffield Terrace, York	YORYM 2005.513, SYO 924	24	1	25	SE 5928 5095	Hunter-Mann, K. 2005. *6 Driffield Terrace, York. An Assessment Report on an Archaeological Excavation.* Unpublished report no. 2005/55 for York Archaeological Trust. Also Tucker, K. 2005. Unpublished osteological notes.
16.	8, High Ousegate, Peter Lane, York*	YATGAZ 1977.30	0	0	2	SE 6034 5173	York Archaeological Trust. 1977. *8; High Ousegate (Peter Lane), York*. Site 1977.30, archive notes.
17.	89, The Mount, York	OSA05EX01	9	0	0	SE 5945 5102	McIntyre, I., and Holst, M. 2006. *89 The Mount, York; Assessment of Skeletal Remains. OSA Report No. OSA05EX01*. Unpublished report.
18.	A19/A64 Interchange Selby Road, Fulford, York	YATGAZ 1997.51 YORYM	1	0	0	SE 6135 4790	York Archaeological Trust. 1997. *A19/A64 Interchange, Fulford Road Improvement Scheme. Report on an Archaeological Watching Brief*. Unpublished field report no. 11.

	Site	Record ID	No. Inhum.	No. Crem.	No. Disartic. contexts	NGR	Reference
19.	All Saints School, Mill Mount Lane, York	06004, SYO 1011	1	0	0	SE 5958 5099	Hopkinson, G. 2006. *All Saint's School, The Mount, York; Archaeological Watching Brief*. Unpublished report no. 06004 by Archaeoscope.
20.	All Saints School, Mill Mount, York	1991/42, SYO 255, EYO 15	4	0	0	SE 5953 5103	MAP Archaeological Consultancy. 1993. *Archaeological Watching Brief – All Saints School, Mill Mount, York.* Unpublished report.
21.	All Saints School, Nunnery Lane, York	OSA02EX01	1	0	0	SE 5973 5133	Bruce, G., and Kausmally, T. 2002. *All Saints School, Nunnery Lane, York; Report on an Archaeological Excavation. OSA Report No. OSA02EX01*. Unpublished report.
22.	All Saints School, Nunnery Lane, York	YATGAZ 1993.15	0	0	1	SE 5973 5133	York Archaeological Trust. 1993. *All Saints School, Nunnery Lane, York. 1993 Evaluation Report Number 2.* Unpublished report.
23.	Apple Tree Farm, Heworth, York	n/a	0	1	0	SE 633 529	Sulosky, C. 2006. A report on Romano-British cremated remains from York. Unpublished report for the Yorkshire Museum.

	Site	Record ID	No. Inhum.	No. Crem.	No. Disartic. contexts	NGR	Reference
24.	Apple Tree Farm, Heworth, York	59/1, EHNMR 635623, YORYM 1974.95?	1	0	0	SE 633 529	This study.
25.	Barbican, York	1987.27, EYO 3965	0	1	0	SE 60870 51209	This study.
26.	Barbican Centre, York	OSA03EV08	1	0	0	SE 6090 5120	Bruce, G. 2003. *The Barbican Centre, York. Report on an Archaeological Evaluation. OSA Report No. OSA03EV08*. Unpublished report.
27.	Barbican, York^	OSA07EX02	7	0	0	SE 60792 51174	Bruce, G., McIntyre, L., and Chamberlain, A. In preparation. *Excavation of the Medieval Church and Cemetery of All Saints, Fishergate*.
28.	Blue Bridge Lane, Fishergate House, York	YBB & YFH 00-04, SYO182	1	5	0	SE 6060 5100	Field Archaeology Specialists. 2005. *Archaeological Excavation and Watching Brief; Blue Bridge Lane and Fishergate House, York (Site YBB & YFH 00-04)*. Unpublished report.

	Site	**Record ID**	**No. Inhum.**	**No. Crem.**	**No. Disartic. contexts**	**NGR**	**Reference**
29.	Blue Bridge Lane, Fishergate, York	1994/, SYO 262 EYO 52	1	0	4	SE 6070 5100	Mike Griffiths and Associates. 1995. *Blue Bridge Lane Archaeology Mitigation Strategy*. Unpublished report.
30.	Castle Yard Cemetery, York	1947.9, EYO 2765, EYO 2766, EYO 2767, EYO 2768	1	0	0	SE 6047 5152	This study.
31.	Cherry Hill, Clementhorpe, York	1989.14, NMRMIC-2960	7	0	0	SE 6027 5117	York Archaeological Trust. 1989. *Cherry Hill, Clementhorpe, York.* Site 1989.14, site summary sheet.
32.	Clementhorpe/Terry Avenue, York	YATGAZ 1986.5	1	1	1	SE 6027 5113	York Archaeological Trust. 1986. *Terry Avenue*. Site 1986.5, archive notes.
33.	Clifford's Tower, York	n/a	1	0	0	SE 604 514	This study.
34.	Clifton Grange Hotel, York^	OSA07WB01	1	0	0	SE 59704 52581	McIntyre, L. 2007. *Watching Brief at Clifton Grange Hotel, York; Osteological Assessment of Skeletal Remains. OSA Report No. OSA07WB01*. Unpublished report.
35.	Clifton, York^	YORYM 1947.8	1	0	0	SE 595 535	This study.

	Site	**Record ID**	**No. Inhum.**	**No. Crem.**	**No. Disartic. contexts**	**NGR**	**Reference**
36.	Clifton, York	HARGM 3630	0	1	0		This study.
37.	Coffin in Hospitium, York^	YORYM 1947.58	1	0	0	SE 59865 52110	This study.
38.	County Hospital, Jewbury; York	YATGAZ 1982.10	10	0	2	SE 6073 5220	This study.
39.	Elmbank Hotel, The Mount, York	OSA99WB06	0	0	1	SE 5922 5094	Hopkinson, G. 1999. *Elmbank Hotel, The Mount, York; Report on an Archaeological Watching Brief. OSA Report No.OSA99WB06*. Unpublished report.
40.	Elmbank Hotel, The Mount, York	YORYM 1977.57	1	0	0	SE 5922 5094	This study.
41.	Elmbank Hotel, The Mount, York	OSA98EV02, 1998.13, SYO 320 EYO110	0	1	0	SE 5922 5094	Hopkinson, G. 1998. *Elmbank Hotel, The Mount, York; Report on an Archaeological Evaluation. OSA Report No. OSA98EV02*. Unpublished report.
42.	Fetter Lane Electricity Substation, York*	OSA98EV07, YORYM 1998.692, SYO 366, EYO 156	1	0	0	SE 6002 5156	Pearson, N., and Dickson, A. 2000. *Electricity Sub-Station, Fetter Lane, York; Evaluation and Watching Brief Report. OSA Report No. OSA98EV07*. Unpublished report.

	Site	**Record ID**	**No. Inhum.**	**No. Crem.**	**No. Disartic. contexts**	**NGR**	**Reference**
43.	Former Foxton's Garage, Leeman Road, York	n/a	0	0	6	SE 5975 5194	York Archaeological Trust. 1998. *Former Foxton's Garage, Leeman Road, York*. *Report on an Archaeological Evaluation*. Unpublished field report no. 4.
44.	Former Starting Gate Pub, Tadcaster Road, York	YORYM 2003.303, EYO 299	3	0	4	SE 5869 4966	McComish, J. 2010. *Roman Occupation at the Former Starting Gate Public House, 42-50 Tadcaster Road, Dringhouses, York*. Unpublished report, available at: http://www.iadb.co.uk/i2/i2_pub.php?PP=39
45.	Former TVA Compound, Dundas Street, Hungate, York	HUN02, YHN03	1	2	1	SE 6070 5187	Field Archaeology Specialists. 2003. *Former TVA Compound, Hungate, York; Archaeological Evaluation (Site HUN02)*. Unpublished report.
46.	Fulford Pumping Station, York^	YORYM 1949.51	1	0	0	SE 60624 49655	This study.
47.	Heslington East, York	HE08	1	0	0	SE 640 506	Holst, M. 2008. *Osteological Analysis, Heslington East, York.* Unpublished report no. 1108. Prepared for the Department of Archaeology at the University of York.

	Site	Record ID	No. Inhum.	No. Crem.	No. Disartic. contexts	NGR	Reference
48.	Heslington East, York	HE09	2	0	0	SE 640 506	Holst, M. 2009. *Osteological Analysis, Heslington East, York*. Unpublished report no. 0609. Prepared for the Department of Archaeology at the University of York.
49.	Heworth Croft^	HEW06, SYO 1041	0	2	0	SE 61121 52688	Fern, C. 2007. *Report on the Archaeological Watching brief at Heworth Croft, York (Site code HEW 06).* Unpublished report by Fern Archaeology for Mike Griffiths and Associates.
50.	Heworth Croft	YHC04, SYO 866 (incorporates material from YHV04 SYO 534)	0	3	0	SE 6102 5261	Field Archaeology Specialists. 2004. *Heworth Croft, Heworth, York. Archaeological Evaluation Phase 2.* Unpublished report.
51.	Heworth Green, York	58220, NMR SE 65 SW 34	0	1	0	SE 6119 5275	This study.
52.	Holgate Bridge, York	YORYM H1058, and YORYM HG 214	0	2	0	SE 588 512	This study.

	Site	**Record ID**	**No. Inhum.**	**No. Crem.**	**No. Disartic. contexts**	**NGR**	**Reference**
53.	IECC Compound, York Railway Station, York	SYO 385, EYO176, EYO 408	0	0	8	SE 5935 5151	Field Archaeology Specialists. 1999. *Archaeological Evaluation. IECC Compound, York Railway Station*. Unpublished report.
54.	Jewbury, York	YATGAZ 1983.5	0	2	0	SE 6073 5220	This study.
55.	Knavesmire Manor Hotel, Tadcaster Road, York	2001.443	1	0	0	SE 5896 5017	York Archaeological Trust. 2001. *Knavesmire Manor Hotel, Tadcaster Road, York. Report on an Archaeological Watching Brief*. Unpublished field report no. 5.
56.	Laurens Manor, Lawrence Street, York	YLM05, SYO 959	1	0	0	SE 6164 5137	Field Archaeology Specialists. 2006. *Laurens Manor, Lawrence Street, York; post excavation assessment (Site YLM05)*. Unpublished report.
57.	Lord Mayor's Walk, York*	OSA04WB35, SYO 558	1	0	0	SE 6060 58.5240	Robinson, T. 2005. *Lord Mayor’s Walk, York; Report on an Archaeological Watching Brief. OSA Report no. OSA04WB35*. Unpublished report.

	Site	Record ID	No. Inhum.	No. Crem.	No. Disartic. contexts	NGR	Reference
58.	Mill Mount Extension, York	OSA01EV09	1	0	0	SE 5946 5108	Diamond, S., and Robinson, T. 2002. *Mill Mount Extension, York; Report on an Archaeological Evaluation. OSA Report No. OSA01EV09*. Unpublished report.
59.	Mill Mount, The Mount, York	YMM04	13	2	24	SE 5945 5102	Field Archaeology Specialists. 2005. *Post-excavation Assessment, Mill Mount, York (Site YMM04).* Unpublished report.
60.	Mill Mount, The Mount, York	YMM05	6	0	10	SE 5945 5102	Field Archaeology Specialists. 2006. *Mill Mount, The Mount, York; Archaeological Watching Brief (Site YMM05-6).* Unpublished report.
61.	Mill Mount, York	OSA02EV12, SYO 821, EYO 617	1	0	0	SE 5945 5102	Palmer, F. 2002. *Mill Mount, York; Report on an Archaeological Evaluation. OSA Report No. OSA02EV12*. Unpublished report.
62.	Mill Mount, York	OSA04WB08, SYO 837, EYO 632	1	0	0	SE 5946 5108	Kausmally, T. 2004. *Mill Mount, York; Report on an Archaeological Watching Brief. OSA Report No. OSA04WB08*. Unpublished report.
63.	Monkbridge Gasometer, Monkbridge, York^	n/a	5	0	0	SE 6098 5267	This study.

	Site	**Record ID**	**No. Inhum.**	**No. Crem.**	**No. Disartic. contexts**	**NGR**	**Reference**
64.	Moss Street Depot	YMD03, SYO 461, EYO 289	3	0	5	SE 59691 51234	Field Archaeology Specialists. 2006. *Moss Street Depot, York; Archaeological Excavation (Site YMD04)*. Unpublished report.
65.	Moss Street Depot^	YMD014, YMD04, SYO 1076	1	0	9	SE 59691 51234	Field Archaeology Specialists. 2006. *Moss Street Depot, York; Archaeological Excavation (Site YMD04)*. Unpublished report.
66.	Mount School, Dalton Terrace, York^	YORYM 2003.290, SYO 538	0	0	4	SE 5932 5106	Milner, B. and Johnson, M. 2004. *The Mount School, Dalton Terrace, York. A Report on an Archaeological Watching Brief*. Unpublished field report for York Archaeological Trust; Johnson, M. 2004. *The Mount School, Dalton Terrace, York. A Report on an Archaeological Excavation*. Unpublished field report for York Archaeological Trust.
67.	Opposite Holgate House, York	YORYM 1971.305	2	0	0	SE 5875 5125	This study.

	Site	Record ID	No. Inhum.	No. Crem.	No. Disartic. contexts	NGR	Reference
68.	Platform 1, York Railway Station, York^	YORYM 2001.4429, SYO 697 EYO 491	1	0	0	SE 59610 51606	York Archaeological Trust. 2001. *Platform 1, York Railway station, York. Report on an Archaeological Excavation of a Human Burial*. Unpublished field report no. 3.
69.	Platform 14, York Railway Station^	LEEDM. D. T. 2588	3	0	0	SE 5953 5174	This study.
70.	Railway offices, Holgate Road, York	n/a	3	0	0	SE 595 514	Wenham, P. 1960. Seven Archaeological Discoveries in Yorkshire. *Yorkshire Archaeological Journal* 40: 298-328.
71.	Richardson Street, York	YATGAZ 1978.1010	1	0	0	SE 6021 5069	This study.
72.	Roman Graveyard, York	391	2	0	0		This study.
73.	Rowans, York	YORYM 1974.120	3	0	0		This study.
74.	Royal York Hotel, York	OSA99EX02, YORYM 1999.804	13	0	0	SE 59666 51780	This study.
75.	Royal York Hotel, York	YORYM 1999.940, EHNMR 1310194	3	0	0	SE 59666 51780	This study.

	Site	**Record ID**	**No. Inhum.**	**No. Crem.**	**No. Disartic. contexts**	**NGR**	**Reference**
76.	Shearsmith's Building, Lion and Lamb Car Park, 35-41, Blossom Street, York	YATGAZ 1989-90.21	32	0	2	SE 5973 5130	Stroud, G. 1990. *The human bones from 35-41 Blossom Street*. Unpublished report for York Archaeological Trust. Also this study.
77.	Skeldergate Postern, York*^	YORYM 1977.61	3	0	0	SE 60233 51449	This study.
78.	St. Mary's Abbey, York	n/a	1	0	0		This study.
79.	Stone Coffin 1, York Railway, York	1947.21	1	0	0		This study.
80.	Stone Coffin 2, York Railway, York	1947.17	1	0	0		This study.
81.	Stone Coffin 3, York Railway, York	1947.29	1	0	0		This study.
82.	Sycamore Terrace, York	YORYM 1977.60	1	0	0	SE 595 522	Leach, S., Eckhart, H., Chenery, C., Müldner, G., and Lewis, M. 2010. A Lady of York: migration, ethnicity and identity in Roman Britain. *Antiquity* 84: 131-145. Also this study.

	Site	Record ID	No. Inhum.	No. Crem.	No. Disartic. contexts	NGR	Reference
83.	The Bar Convent, York^	n/a	18	0	1	SE 59734 51384	This study.
84.	The Fox, Tadcaster Road, Dringhouses, York	YATGAZ 1997.70 YORYM, SYO 288, EYO 78	1	0	0	SE 5865 4958	York Archaeological Trust. 1997. *The Fox Public House, Tadcaster Road, Dringhouses, York. Archaeological Investigation Report.* Unpublished field report no. 18.
85.	The Mount School, Driffield Terrace, York	YATGAZ 1987.15	13	0	1	SE 5924 5098	This study.
86.	The Mount School, Love Lane, York	YORYM 2000.501, SYO 675 EYO 469	0	0	1	SE 5913 5108	York Archaeological Trust. 2000. *The Mount School, Love Lane, York. Report on an Archaeological Watching Brief.* Unpublished field report no. 51.
87.	The White House, 10 Clifton, York	YORYM 2001.8437, SYO 778 EYO 573	2	0	0	SE 5973 5265	York Archaeological Trust. 2002. *The White House, 10 Clifton, York. Report on an Archaeological Watching Brief.* Unpublished field report no. 4.

	Site	**Record ID**	**No. Inhum.**	**No. Crem.**	**No. Disartic. contexts**	**NGR**	**Reference**
88.	Transco Gas Main, Avenue Terrace, York	YORYM 2000.587, SYO 673 EYO 467	0	0	1	SE 5954 5292	York Archaeological Trust. 2000. *Transco Gas Main, Avenue Terrace, York. Report on an Archaeological Watching Brief.* Unpublished field report no. 45.
89.	Trentholme Drive, York	MYO 2160, YORYM 1971: 303, EYO 2831-EYO 2833 MYO2169, 56612, NMR SE 55 SE 9, EYO 2824-EYO 2827?	282 (this study)	27 (this study)	1 (this study)	SE 5925 5075	Wenham, L. P. 1968. *The Romano-British Cemetery at Trentholme Drive, York.* Ministry of Public Building and Works Archaeological Report No. 5, London, HMSO; Peck, J. J. 2009. *The biological impact of culture contact; a bioarchaeological study of Roman colonialism in Britain*. Unpublished PhD Thesis for Ohio State University. Also this study.
90.	York Railway Station, Station Road, York	YATGAZ 1983.47	1	0	0	SE 5965 5164	York Archaeological Trust. 1983. *York Railway Station, Station Road, York*. Site 1983.47, archive notes.

	Site	Record ID	No. Inhum.	No. Crem.	No. Disartic. contexts	NGR	Reference
91.	York Railway Station, York	MYO 2010, 56611, NMR SE 55 SE 8, EYO 2793-EYO 2818, YORYM 1947.1-60 (unless stated otherwise)	59	2	10	SE 5965 5164	This study.
92.	York Tile Tomb, Mount Villa, York	1947.11, NMR_NATINV-56379, 56379, NMR SE 54 NE 7	1	0	0	SE 5870 4981	This study.
93.	Yorkshire Museum, York*	Report No. 0610	1	0	0	SE 59988 52253	Holst, M. 2011. *Osteological Analysis, Yorkshire Museum, York.* Unpublished report no. 0610. Prepared for the Yorkshire Museum.
94.	York Castle, York	58178, NMR SE 65 SW 16	4	0	0	SE 605 514	Ramm, H. G. 1958. Roman burials from Castle Yard, York. *Yorkshire Archaeological Journal* 39: 400-418

Appendix 2: Gazetteer of Omitted Sites

This gazetteer lists sites that have been recorded as yielding human skeletal remains, but for which no osteological data or remains could be located or observed (the number of each burial type apparently present at each site is recorded below in the third, fourth and fifth columns of the table). These sites include antiquarian findspots and observations, sites for which no report was produced or where the report has been lost and the remains reburied, and sites where the location of excavated human skeletal remains is unknown. Several sites in this Appendix (from the 1962 Royal Commission publication) were included in the spatial density analysis conducted in this study. These are marked with a ^. All other sites in this Appendix were not included in the present study because of lack of observable osteological data or skeletal remains.

For some sites, the written records are vague and the quantity of remains found or observed is also unknown. Therefore the “Reference” column of the below table may refer to either specific publications or databases where the site is mentioned. Where basic antiquarian osteological data (i.e. age, sex etc) was available, data was not included in the study as methods of analysis were considered to be of questionable accuracy.
In some cases, multiple entries in the following table may also refer to the same site, or a site that has already been included in the study and is listed in Appendix 1; however lack of data means that it is not possible to determine if this is the case. This is something that future researchers should bear in mind when dealing with these sites.

Sites with a * are located within the confines of the Roman settlement.

Site	**Record ID**	**No. Inhum.**	**No. Crem.**	**No. Disartic. contexts**	**NGR**	**Reference**
39 Blossom Street, Lion and Lamb Car Park, York (included in later analysis of site YATGAZ 1989-90.21?)	NMRMIC 2962	1	0	0	SE 5969 5131	Archaeology Data Service
Askham Richard, York	MYO 202, FYO 13?	?	?	?	SE 5380 4900	City of York Historic Environment Record, via Heritage Gateway
Askham Richard, York	MYO 203	?	?	?	SE 5380 4900	City of York Historic Environment Record, via Heritage Gateway
Corellia Optata cremation burial	N/A	0	1	0	?	Yorkshire Museum
Baile Hill, York^	EYO 2834-7?	1	1	0	SE 60217 51242	Royal Commission on Historical Monuments (England). 1962. *An inventory of the historical monuments in the city of York. Volume 1, Eburacum: Roman York*. London, HMSO: 107
Bishopthorpe Road, Nun Ing, York	MYO 65	1?	?	?	SE 6005 4963	City of York Historic Environment Record, via Heritage Gateway
Blossom Street Roman Cemetery, York	MYO 2203, EYO 2820-EYO 2823	5	1	0	SE 5962 5137	City of York Historic Environment Record, via Heritage Gateway

Site	**Record ID**	**No. Inhum.**	**No. Crem.**	**No. Disartic. contexts**	**NGR**	**Reference**
Burton Stone Lane, Clifton, York^	56608, NMR SE 55 SE 5	0	6?	0	SE 59595 52752	Royal Commission on Historical Monuments (England). 1962. *An inventory of the historical monuments in the city of York. Volume 1, Eburacum: Roman York*. London, HMSO: 73; Pastscape
Cherry Hill Lane, Clementhorpe, York	YATGAZ 1988.9, EYO 3394	Yes	?	?	SE 6027 5118	Archaeology Data Service
Clarence Street, York^	58218, NMR SE 65 SW 32	13?	?	?	SE 60374 52845/SE 60306 52767	Royal Commission on Historical Monuments (England). 1962. *An inventory of the historical monuments in the city of York. Volume 1, Eburacum: Roman York*. London, HMSO: 71
Clementhorpe, York^	58216, NMR SE 65 SW 30, EYO 2838	3	0	0	SE 60202 51166/SE 59936 51143	Royal Commission on Historical Monuments (England). 1962. *An inventory of the historical monuments in the city of York. Volume 1, Eburacum: Roman York*. London, HMSO: 107-8

Site	**Record ID**	**No. Inhum.**	**No. Crem.**	**No. Disartic. contexts**	**NGR**	**Reference**
Clifton Fields, York^	56609, NMR SE 55 SE 6, EYO 2785, EYO 2786, EYO 2787, EYO 2788	1	6	0	SE 59336 52498	Royal Commission on Historical Monuments (England). 1962. *An inventory of the historical monuments in the city of York. Volume 1, Eburacum: Roman York*. London, HMSO: 73; Pastscape
Dalton Terrace, York	YATGAZ 1980.1034	1?	?	?	SE 5913 5109	Archaeology Data Service
Exhibition Square, York^*	EYO 2778?	0	1	0	SE 60065 52208	Royal Commission on Historical Monuments (England). 1962. *An inventory of the historical monuments in the city of York. Volume 1, Eburacum: Roman York*. London, HMSO: 72
Fishergate Roman Cemetery, York	MYO 2021, 58217, NMR SE 65 SW 31, EYO 2769, EYO 2770, EYO 2771, EYO 2772	0	1-9?	0	SE 6075 5104	Royal Commission on Historical Monuments (England). 1962. *An inventory of the historical monuments in the city of York. Volume 1, Eburacum: Roman York*. London, HMSO: 69; City of York Historic Environment Record, via Heritage Gateway; Pastscape

Site	Record ID	No. Inhum.	No. Crem.	No. Disartic. contexts	NGR	Reference
Fox and Roman, Tadcaster Road, York	MYO 2032	?	?	?	SE 5864 4955	City of York Historic Environment Record, via Heritage Gateway
Fulford, York	MYO 220, FYO 31?	?	?	?	SE 6020 4810	City of York Historic Environment Record, via Heritage Gateway
Grange Garth Brick Tomb, York	MYO 2034	?	?	?	SE 60703 50724	City of York Historic Environment Record, via Heritage Gateway
Green Hammerton (same as MNY 18277?)	55088, NMR SE 45 NE 9	1	0	0	SE 4805 5703	Yorkshire Archaeological Journal. 1972. Yorkshire Archaeological Register: 1971. *Yorkshire Archaeological Journal* 44: 219; Pastscape
Heslington, York	58221, NMR SE 65 SW 35, MYO 243, FYO 52, MYO 244	1	0	0	SE 6300 5067	City of York Historic Environment Record, via Heritage Gateway; Pastscape
Heworth Without, York	MYO 265, FYO 73	?	?	?	SE 6310 5310	City of York Historic Environment Record, via Heritage Gateway
Heworth Without, York	MYO 268	?	?	?	SE 6325 5322	City of York Historic Environment Record, via Heritage Gateway
Heworth Without, York	MYO 270	?	?	?	SE 6325 5322	City of York Historic Environment Record, via Heritage Gateway
Heworth Without, York	MYO 277	?	?	?	SE 6300 5300	City of York Historic Environment Record, via Heritage Gateway

Site	**Record ID**	**No. Inhum.**	**No. Crem.**	**No. Disartic. contexts**	**NGR**	**Reference**
Heworth, York	58219, NMR SE 65 SW 33	?	2	?	SE 6137 5243	Royal Commission on Historical Monuments (England). 1962. *An inventory of the historical monuments in the city of York. Volume 1, Eburacum: Roman York*. London, HMSO: 70; Pastscape
Holgate Villa, Holgate, York (part of Wenham's Trentholme Drive excavation?)	EHNMR 635502, EHNMR 658762, MYO 2245	5?	?	?	SE 5907 5122	Royal Commission on Historical Monuments (England). 1962. *An inventory of the historical monuments in the city of York. Volume 1, Eburacum: Roman York*. London, HMSO: 94? ; Archaeology Data Service; City of York Council Sites and Monuments Record Search.
Holgate, York^	56624, NMR SE 55 SE 13	2?	0	1?	SE 58347 51311	Royal Commission on Historical Monuments (England). 1977. *The City of York. Volume 1: Eboracum: Roman York: Addendum.* London, HMSO: 106; Pastscape

Site	**Record ID**	**No. Inhum.**	**No. Crem.**	**No. Disartic. contexts**	**NGR**	**Reference**
Knavesmire, York	58087, NMR SE 64 NW 3	Yes	?	?	SE 6005 4963	Society of Antiquaries. 1773. Extract of two letters from Dr. John Burton of York, to Dr. Ducarel, concerning Roman Antiquities discovered in Yorkshire, 1770. *Archaeologia, or, Miscellaneous Tracts Relating to Antiquity* 2. The Society of Antiquaries, London: 181; Pastscape
Lawrence Street, York	N/A (in RCHME 1962: 70)	?	0	0	SE 6126 5177	Royal Commission on Historical Monuments (England). 1962. *An inventory of the historical monuments in the city of York. Volume 1, Eburacum: Roman York*. London, HMSO: 70
Monkgate and Lord Mayor's Walk, York*	EYO 2773?	2?	0	0	SE 606 523	Royal Commission on Historical Monuments (England). 1962. *An inventory of the historical monuments in the city of York. Volume 1, Eburacum: Roman York*. London, HMSO: 71
Monument with no name, Appleton Roebuck	MNY 10942, NMR SE 53 NE 5	1	0	0	SE 556 399	North Yorkshire Historic Environment Record, via Heritage Gateway.

Site	**Record ID**	**No. Inhum.**	**No. Crem.**	**No. Disartic. contexts**	**NGR**	**Reference**
Monument with no name, Raskelf, Hambleton	MNY 18406, NMR SE 46 NE 2	?	?	?	SE 484 688	North Yorkshire Historic Environment Record, via Heritage Gateway.
Monument with no name, York	MYO 195	?	?	?	SE 588 498	City of York Historic Environment Record, via Heritage Gateway ; City of York Council Sites and Monuments Record Search
Nunthorpe, York	N/A (in RCHME 1962: 108)	4?	0	0	SE 600 492	Royal Commission on Historical Monuments (England). 1962. *An inventory of the historical monuments in the city of York. Volume 1, Eburacum: Roman York*. London, HMSO: 108
Peasholme Green-Layerthorpe, York	EYO 2773?	2?	0	0	SE 610 520	Home, G. 1924. *Roman York. The legionary headquarters and Colonia of Eboracum*. London, Ernest Benn Ltd; Royal Commission on Historical Monuments (England). 1962. *An inventory of the historical monuments in the city of York. Volume 1, Eburacum: Roman York*. London, HMSO: 71
Pool Beck Roman Burial, Green Hammerton (same as 55088/NMR SE 45 NE 9?)	MNY 18277	1?	0	0	SE 480 570	North Yorkshire Historic Environment Record, via Heritage Gateway.

Site	Record ID	No. Inhum.	No. Crem.	No. Disartic. contexts	NGR	Reference
Rawcliffe Lane^	N/A (in RCHME 1962: 76)	0	1	0	SE 59412 53221	Royal Commission on Historical Monuments (England). 1962. *An inventory of the historical monuments in the city of York. Volume 1, Eburacum: Roman York*. London, HMSO: 76.
Shearsmith's Building, Lion and Lamb Car Park, 35-41 Blossom Street, York (included in later analysis of site YATGAZ 1989-90.21?)	EHNMR 1476400	4	?	?	SE 59 51	Archaeology Data Service
Skelton, York	MYO 288, FYO 96	1	0	0	SE 5680 5630	City of York Historic Environment Record, via Heritage Gateway ; City of York Council Sites and Monuments Record Search
St. Georges Primary School, Winterscale Street, York	YATGAZ 1976.1027	0	Yes	0	SE 6080 5091	Archaeology Data Service; York Archaeological Trust only have an architect’s plan in their site archive

Site	Record ID	No. Inhum.	No. Crem.	No. Disartic. contexts	NGR	Reference
St. Mary's, Bootham Terrace, York^	56605, NMR SE 55 SE 2, EYO 2778, EYO 2779, EYO 2781, EYO 2410, EYO 2411	2	0	0	SE 5980 5239/SE 5978 5242	Royal Commission on Historical Monuments (England). 1962. *An inventory of the historical monuments in the city of York. Volume 1, Eburacum: Roman York*. London, HMSO: 72; Pastscape
Tang Hall Beck/Apple Tree Farm, Heworth Without, York	MYO 108	?	?	?	SE 6325 5322	City of York Historic Environment Record, via Heritage Gateway
Tang Hall Beck/Apple Tree Farm, Heworth Without, York	MYO 109	1	0	0	SE 6325 5322	City of York Historic Environment Record, via Heritage Gateway
Tang Hall Beck/Apple Tree Farm, Heworth Without, York	MYO 110	1	0	0	SE 6325 5322	City of York Historic Environment Record, via Heritage Gateway
The Avenue, Clifton, York^	56610, NMR SE 55 SE 7	Yes	Yes	?	SE 59401 52744	Royal Commission on Historical Monuments (England). 1962. *An inventory of the historical monuments in the city of York. Volume 1, Eburacum: Roman York*. London, HMSO: 74
The Mount School, Dalton Terrace, York	EHNMR 1331311	Yes	?	?	SE 59 51	Archaeology Data Service
Tillmire Farm, York	58093, NMR SE 64 NW 5	0	1	0	SE 629 473	Pastscape

Site	Record ID	No. Inhum.	No. Crem.	No. Disartic. contexts	NGR	Reference
Walmgate-Fossgate, York^	N/A (in RCHME 1962: 69)	1	0	0	SE 60869 51532	Royal Commission on Historical Monuments (England). 1962. *An inventory of the historical monuments in the city of York. Volume 1, Eburacum: Roman York*. London, HMSO: 69
Windmill Lane, Heslington, York	MYO 98	?	?	?	SE 6300 5067	City of York Historic Environment Record, via Heritage Gateway; City of York Council Sites and Monuments Record Search
York (are these specific skeletons part of The Mount/Holgate Villa/Blossom Street?)	NMR_NATINV 56608, NMR SE 55 SE 5	?	Yes	?	SE 596 527	Archaeology Data Service; Pastscape

Appendix 3: Proportional preservation of cranial bones at burial locations on Driffield Terrace vs. all other burial locations in York

These graphs illustrate proportional preservation of individual cranial elements (frontal, left and right parietal, left and right nasal, and left and right maxilla) at burial locations on Driffield Terrace compared to all other burial locations in York.

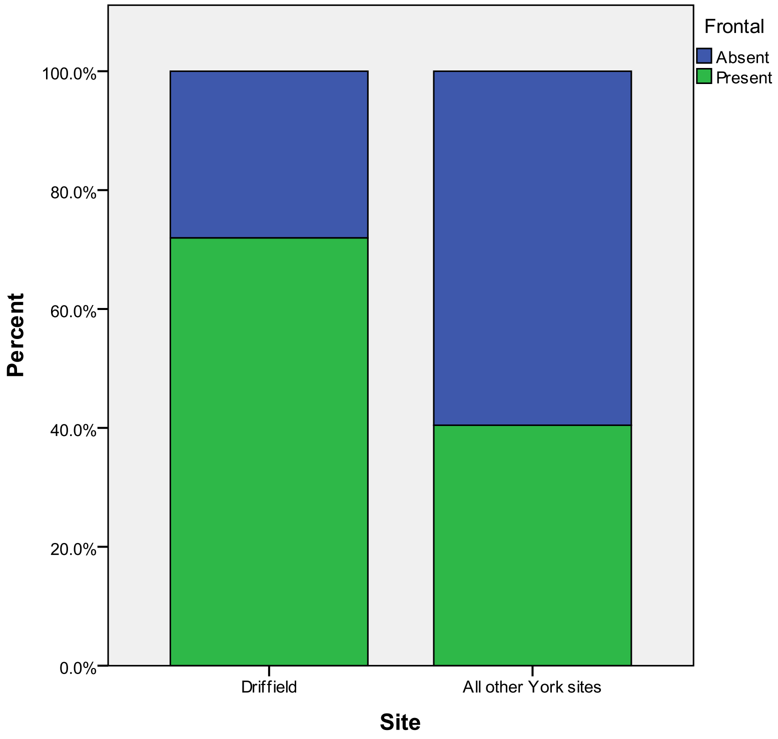


Figure A1: Proportional bar graph illustrating proportional preservation of the frontal at Driffield Terrace vs. all other sites in York

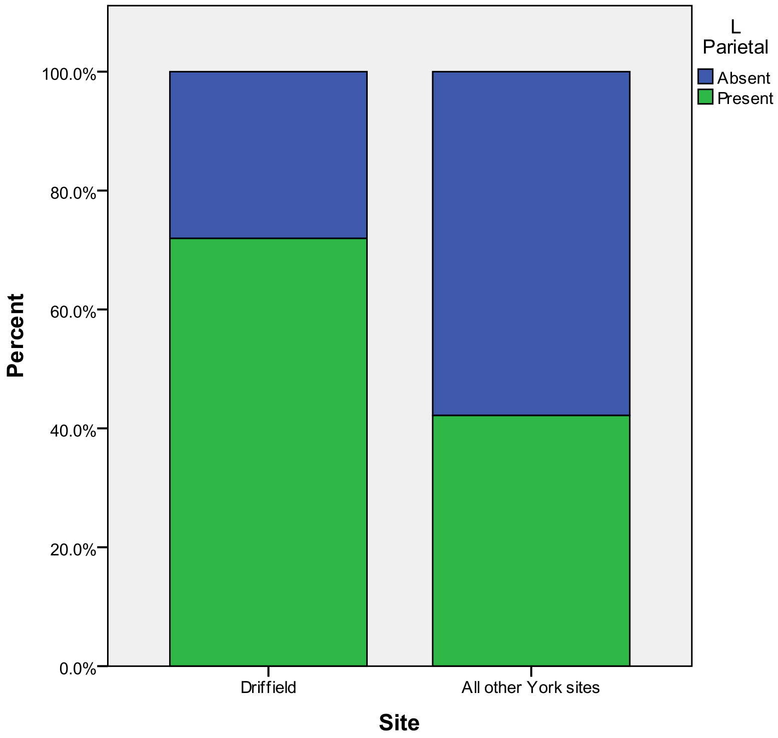


Figure A2: Proportional bar graph illustrating proportional preservation of the left parietal at Driffield Terrace vs. all other sites in York

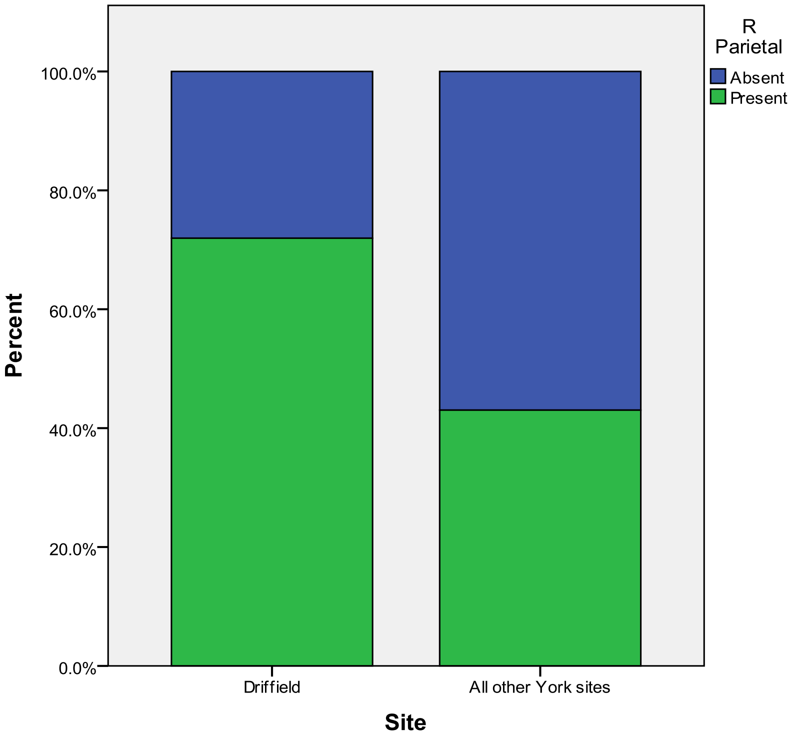


Figure A3: Proportional bar graph illustrating proportional preservation of the right parietal at Driffield Terrace vs. all other sites in York

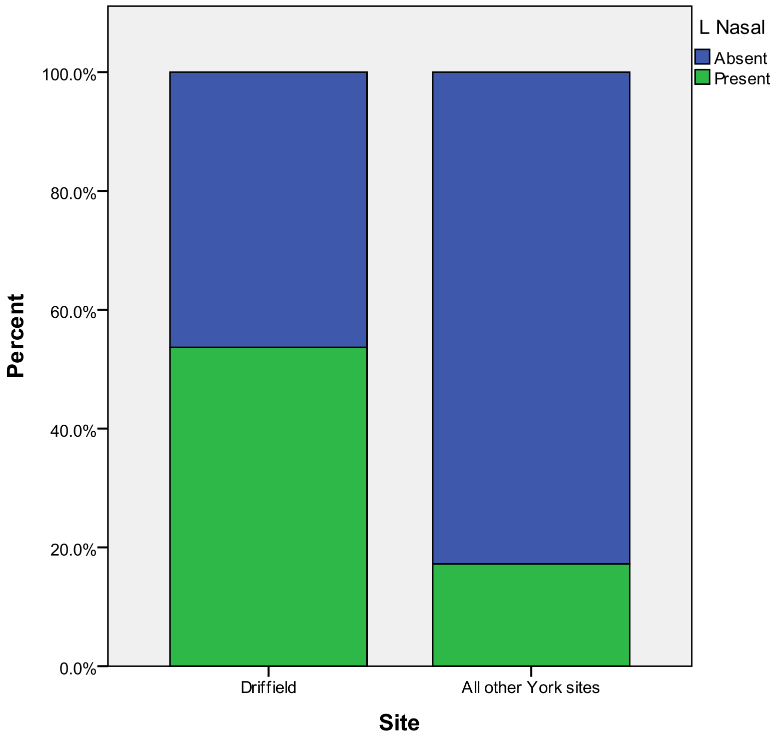


Figure A4: Proportional bar graph illustrating proportional preservation of the left nasal bone at Driffield Terrace vs. all other sites in York

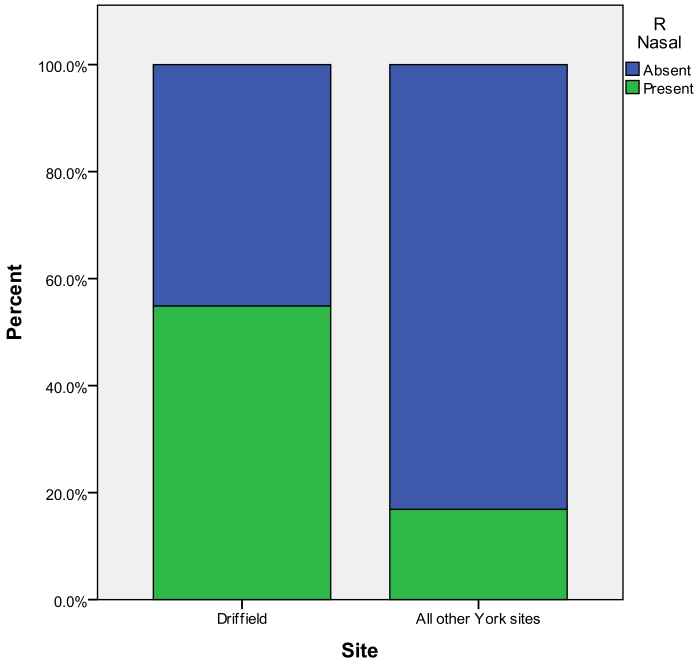


Figure A5: Proportional bar graph illustrating proportional preservation of the right nasal bone at Driffield Terrace vs. all other sites in York

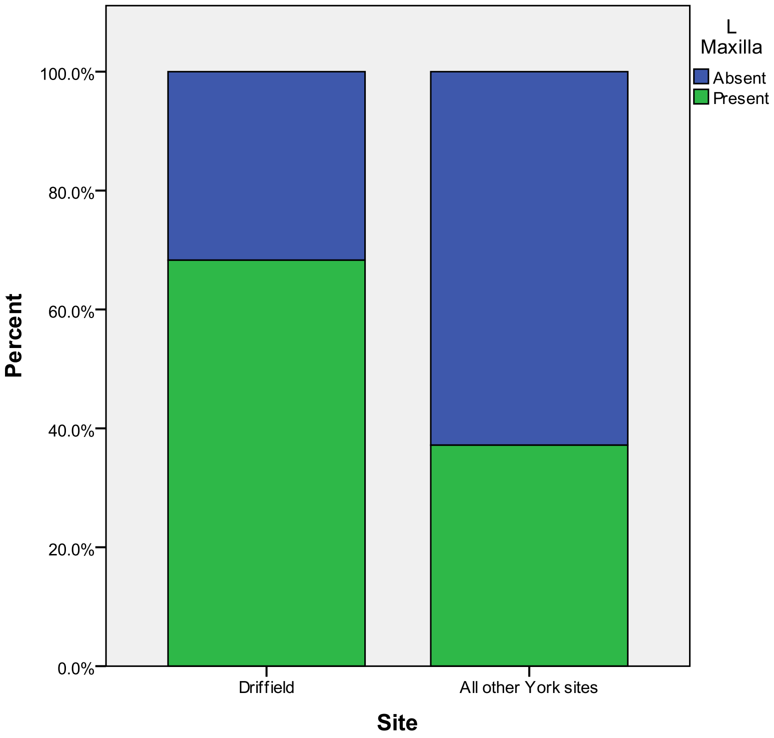


Figure A6: Proportional bar graph illustrating proportional preservation of the left maxilla at Driffield Terrace vs. all other sites in York

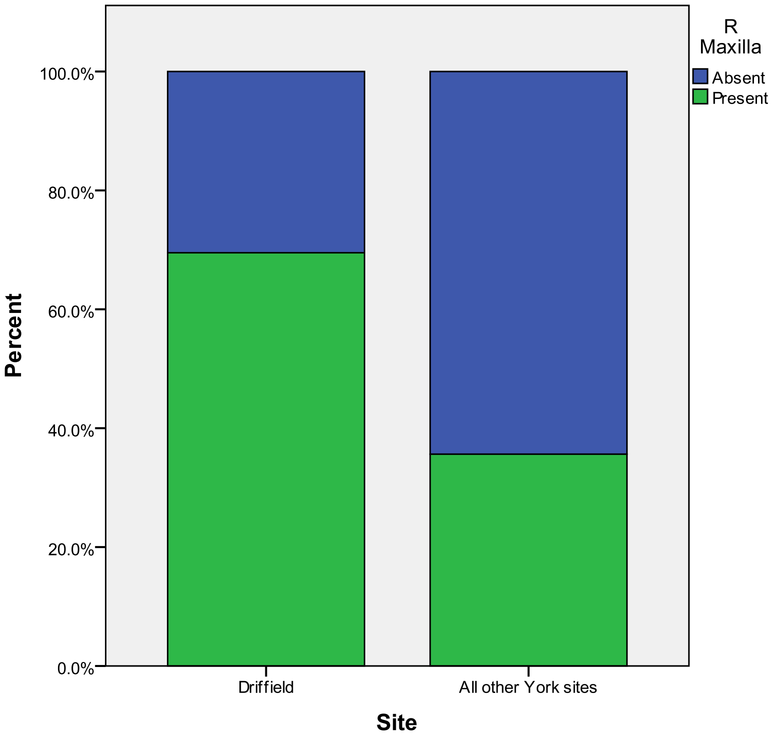


Figure A7: Proportional bar graph illustrating proportional preservation of the right maxilla at Driffield Terrace vs. all other sites in York

Appendix 4: Proportional preservation of post-cranial bones at burial locations on Driffield Terrace vs. all other burial locations in York

These graphs illustrate proportional preservation of individual post-cranial elements (manubrium, left and right ribs, thoracic and lumbar vertebrae, left and right clavicle, left and right scapulae, humeri, ulnae, radii, carpals, metacarpals, proximal, and distal hand phalanges, femora, tibiae, fibulae, tarsals, metatarsals, and proximal, intermediate and distal foot phalanges) at burial locations on Driffield Terrace compared to all other burial locations in York.

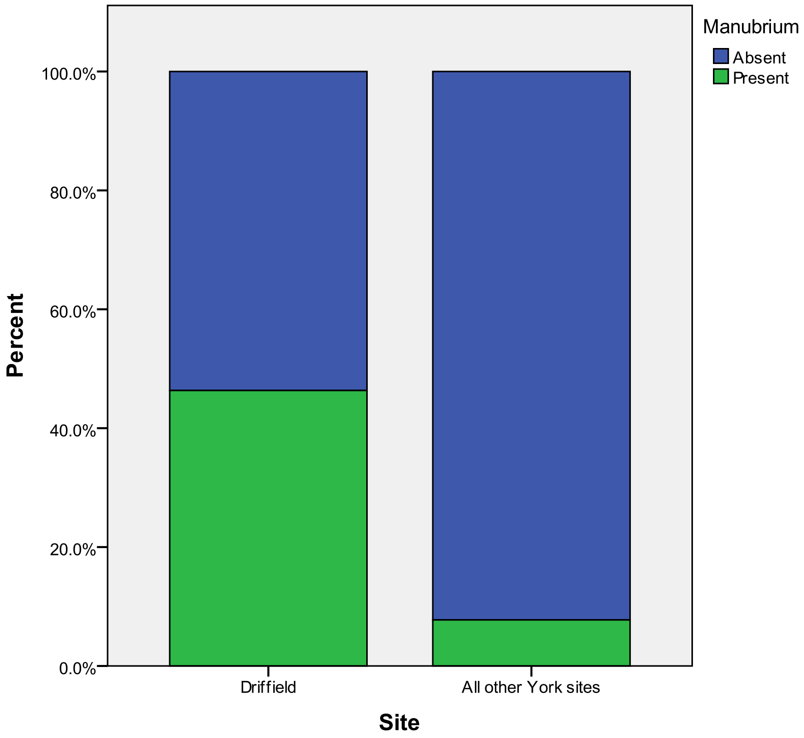


Figure A8: Proportional bar graph illustrating proportional preservation of the manubrium at Driffield Terrace vs. all other sites in York

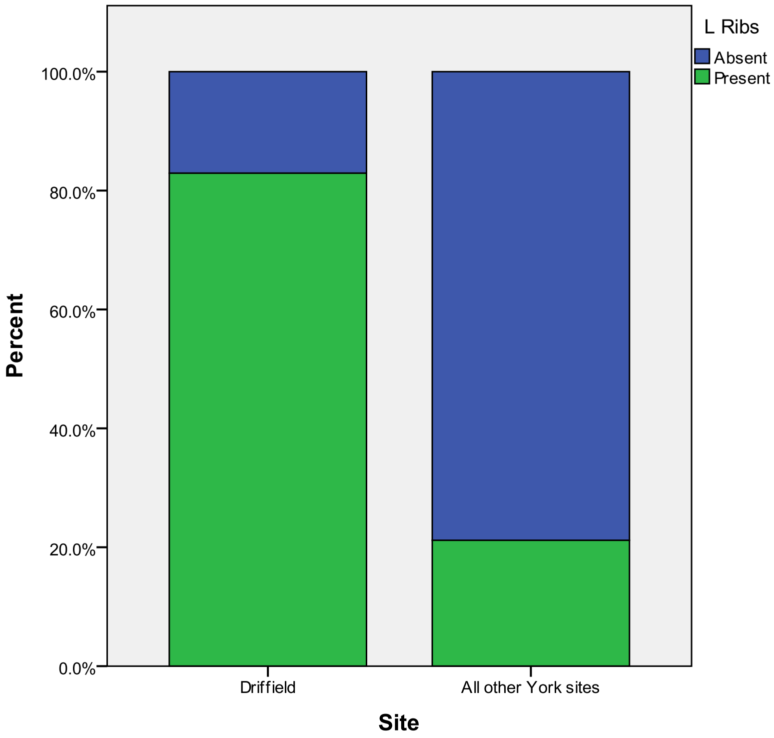


Figure A9: Proportional bar graph illustrating proportional preservation of the left ribs at Driffield Terrace vs. all other sites in York

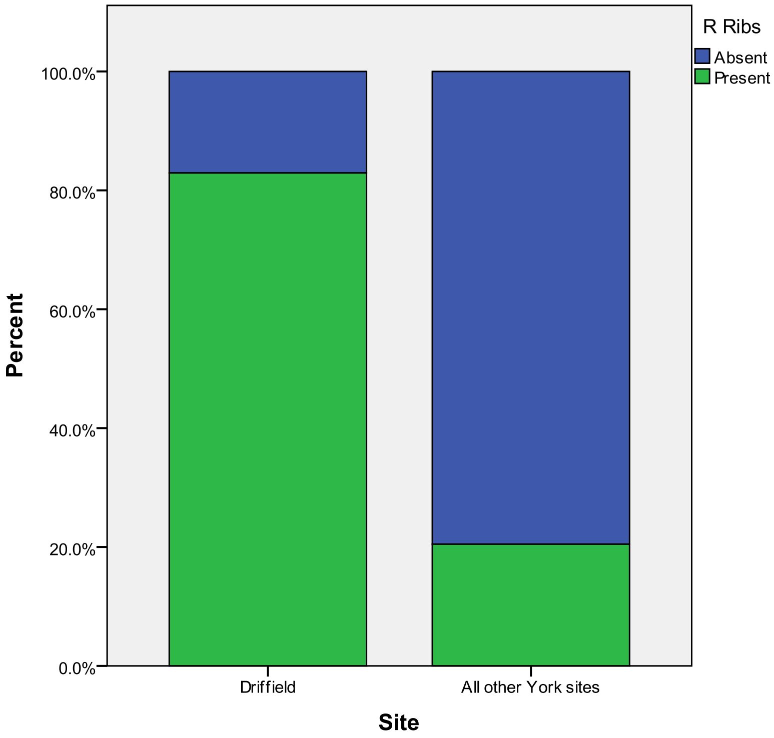


Figure A10: Proportional bar graph illustrating proportional preservation of the right ribs at Driffield Terrace vs. all other sites in York

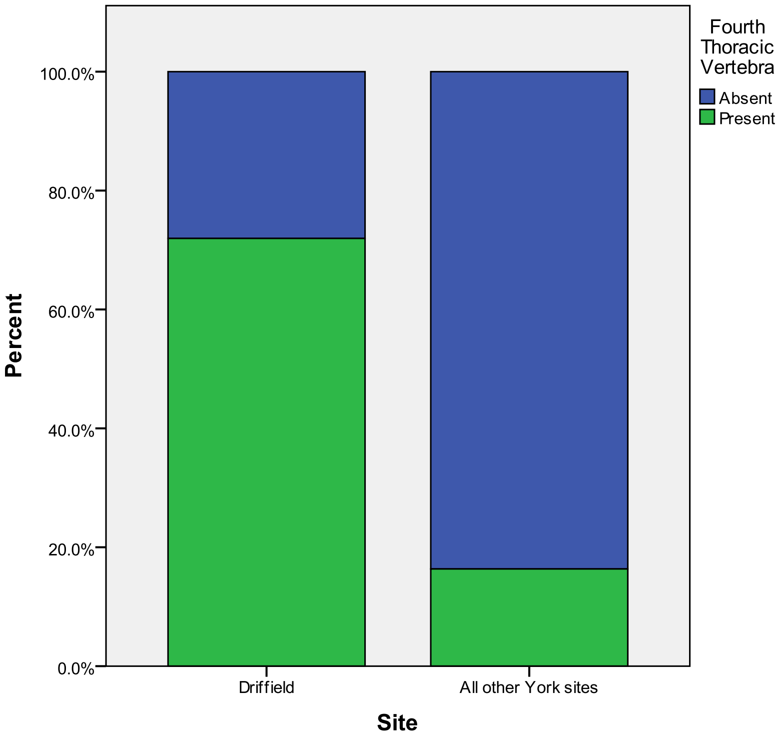


Figure A11: Proportional bar graph illustrating proportional preservation of the fourth thoracic vertebra at Driffield Terrace vs. all other sites in York

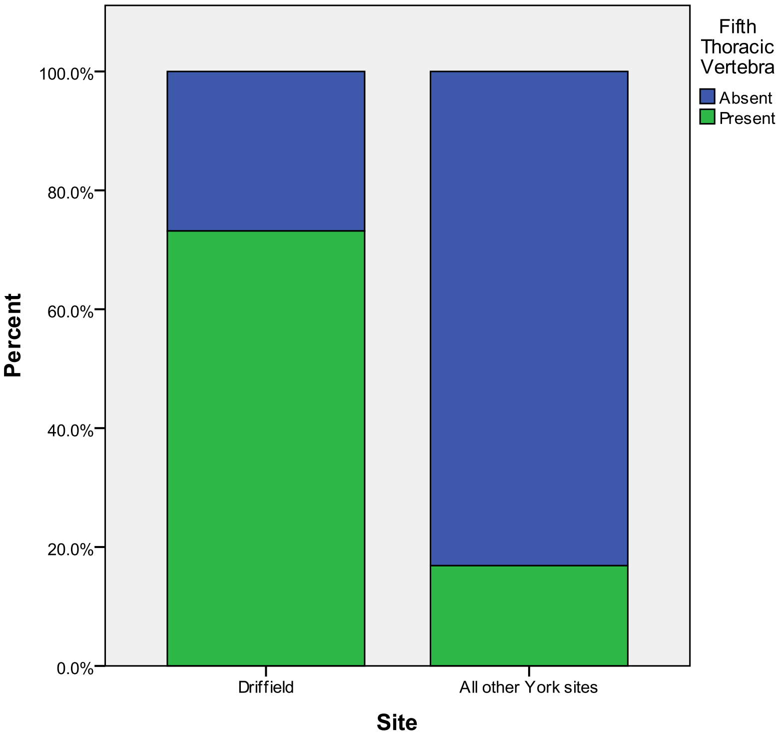


Figure A12: Proportional bar graph illustrating proportional preservation of the fifth thoracic vertebra at Driffield Terrace vs. all other sites in York

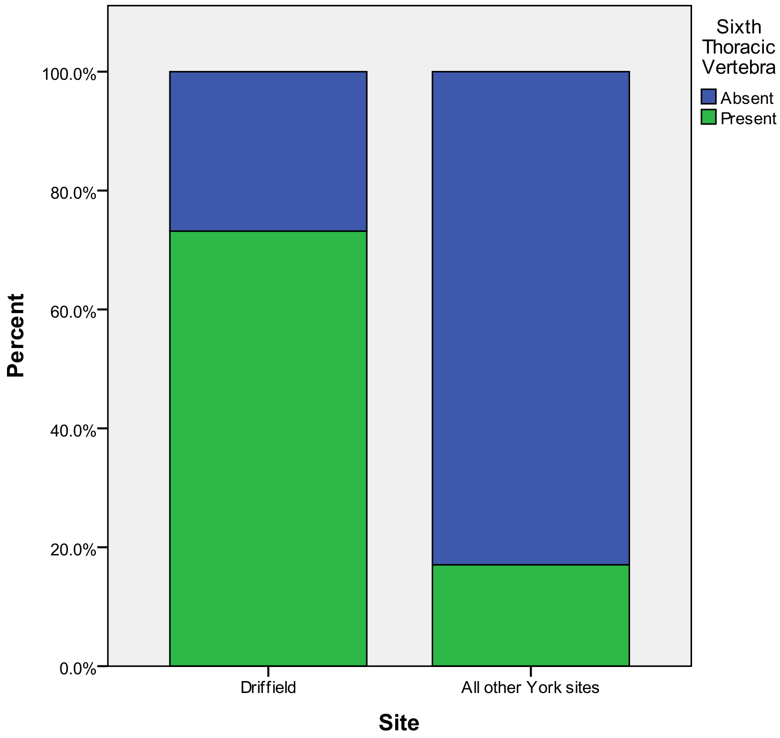


Figure A13: Proportional bar graph illustrating proportional preservation of the sixth thoracic vertebra at Driffield Terrace vs. all other sites in York

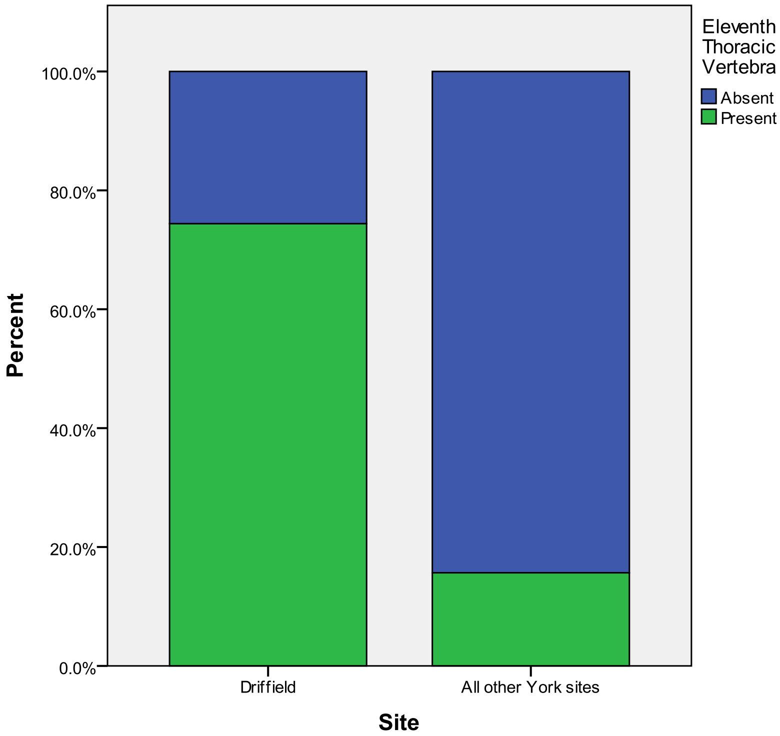


Figure A14: Proportional bar graph illustrating proportional preservation of the eleventh thoracic vertebra at Driffield Terrace vs. all other sites in York

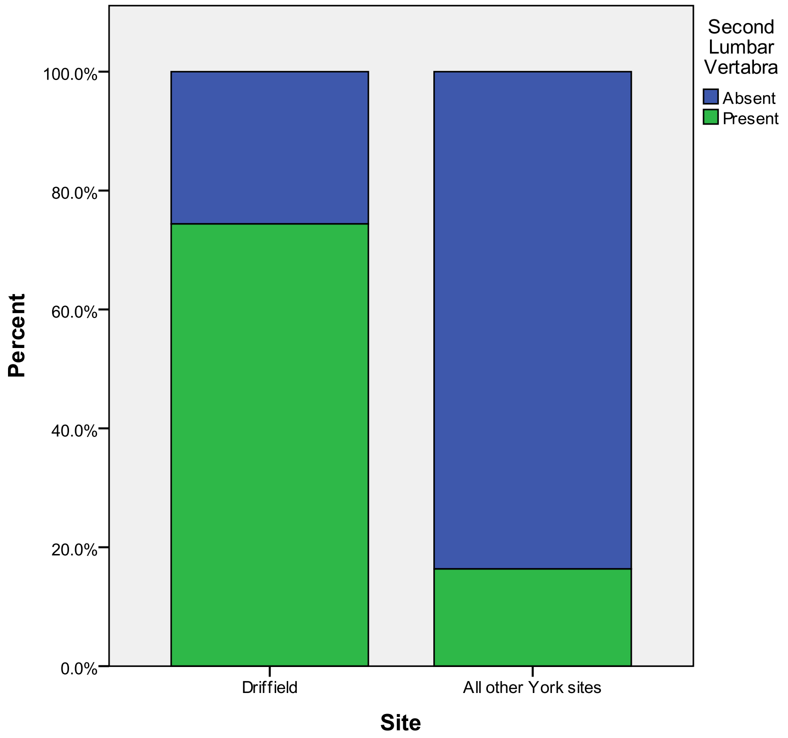


Figure A15: Proportional bar graph illustrating proportional preservation of the second lumbar vertebra at Driffield Terrace vs. all other sites in York

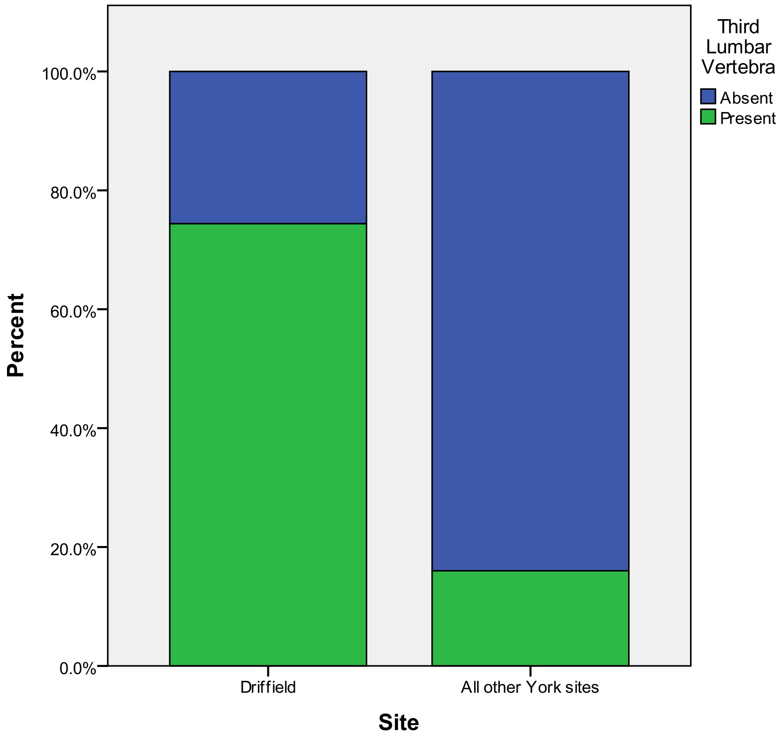


Figure A16: Proportional bar graph illustrating proportional preservation of the third lumbar vertebra at Driffield Terrace vs. all other sites in York

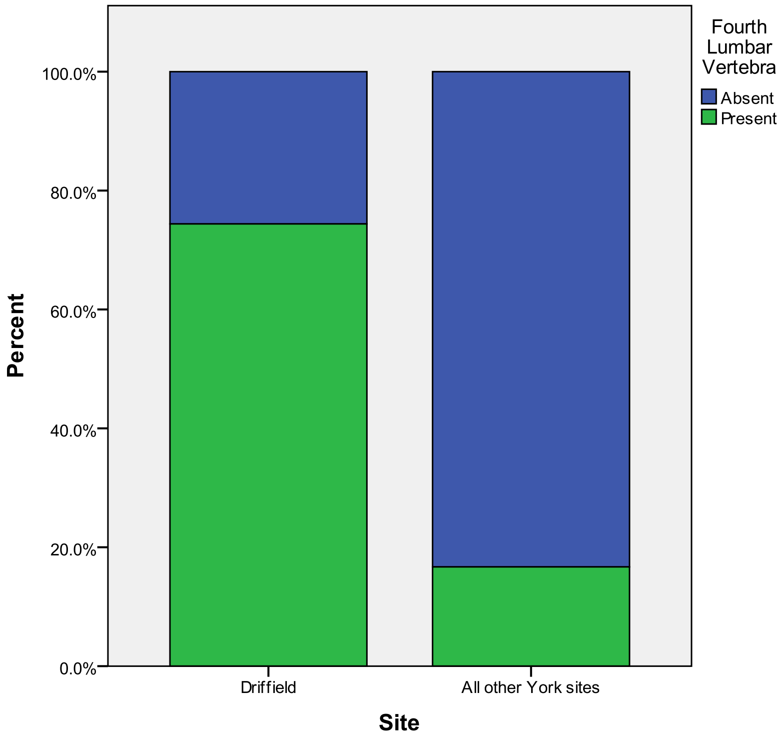


Figure A17: Proportional bar graph illustrating proportional preservation of the fourth lumbar vertebra at Driffield Terrace vs. all other sites in York

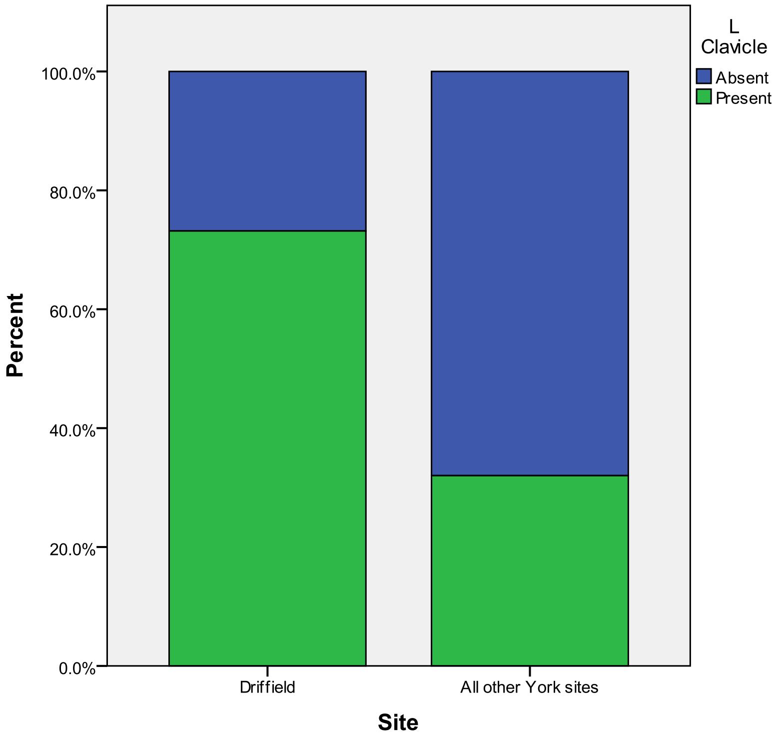


Figure A18: Proportional bar graph illustrating proportional preservation of the left clavicle at Driffield Terrace vs. all other sites in York

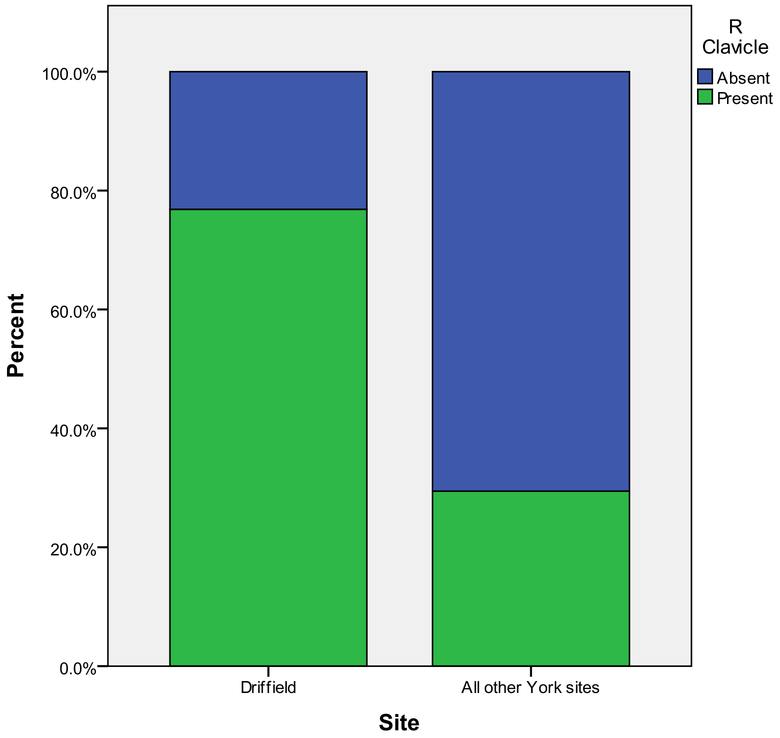


Figure A19: Proportional bar graph illustrating proportional preservation of the right clavicle at Driffield Terrace vs. all other sites in York

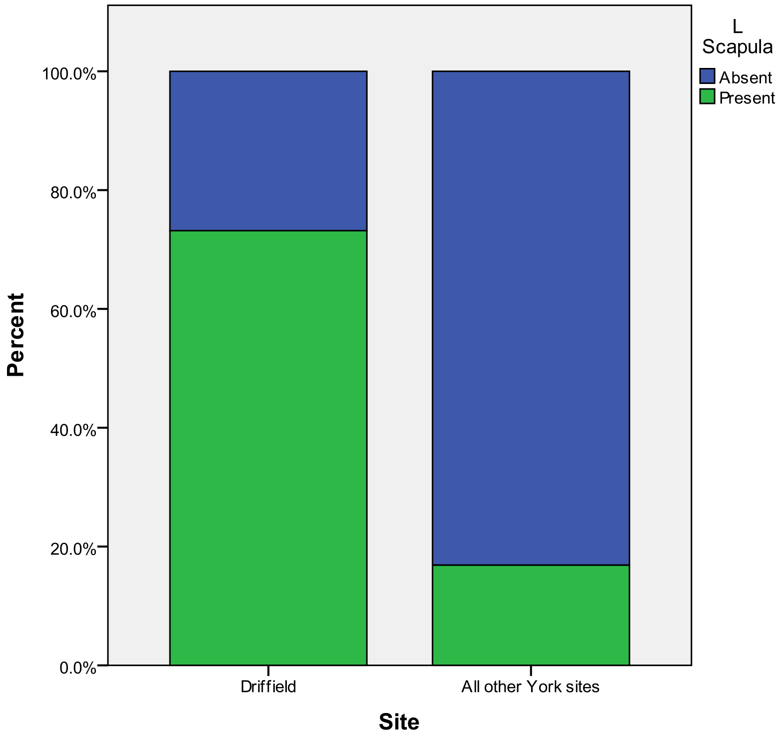


Figure A20: Proportional bar graph illustrating proportional preservation of the left scapula at Driffield Terrace vs. all other sites in York

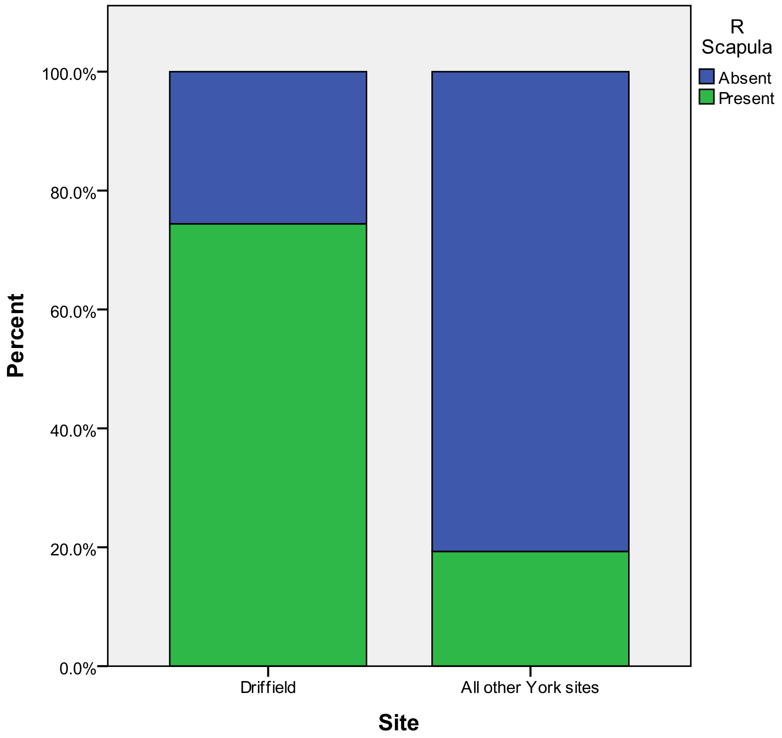


Figure A21: Proportional bar graph illustrating proportional preservation of the right scapula at Driffield Terrace vs. all other sites in York

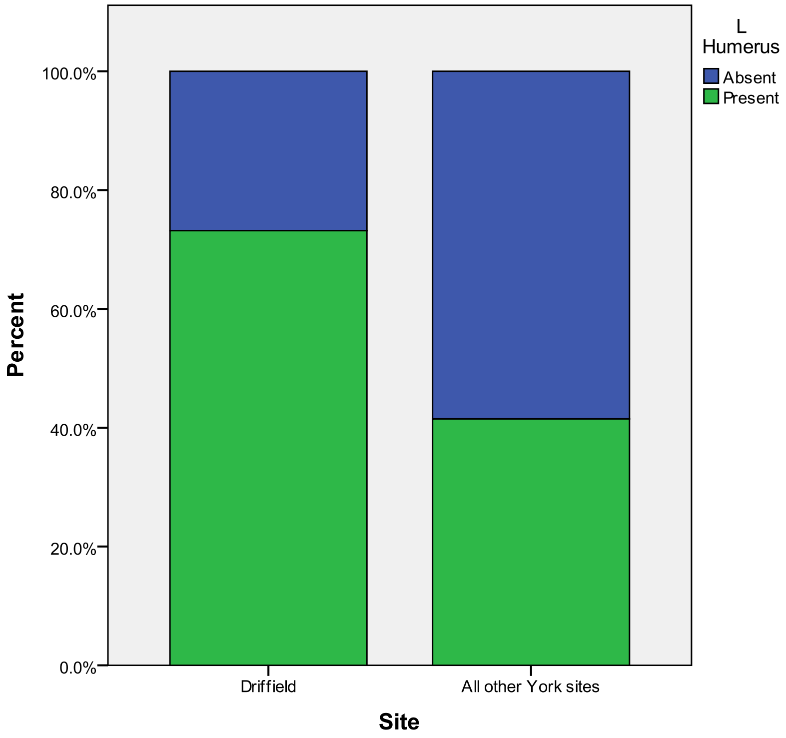


Figure A22: Proportional bar graph illustrating proportional preservation of the left humerus at Driffield Terrace vs. all other sites in York

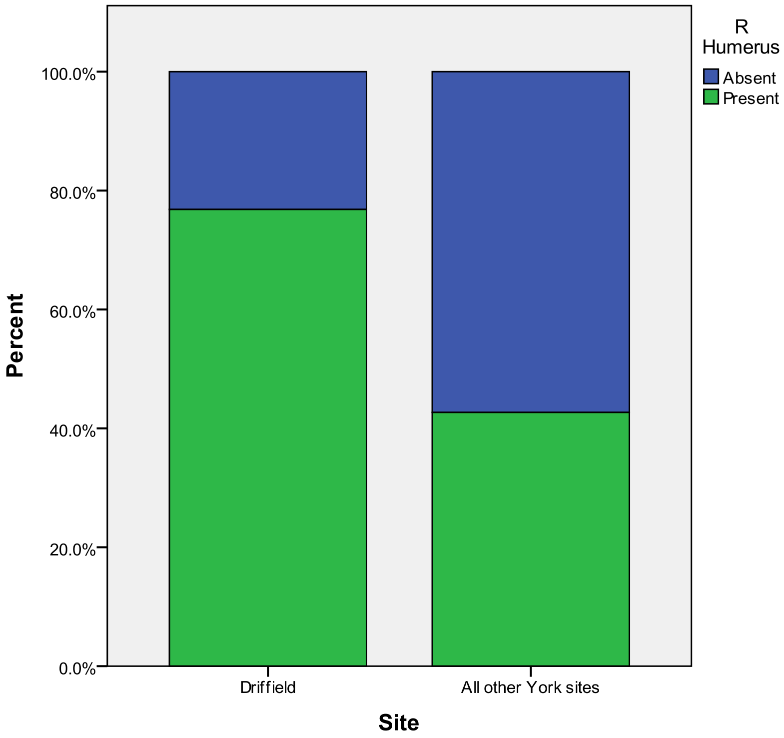


Figure A23: Proportional bar graph illustrating proportional preservation of the right humerus at Driffield Terrace vs. all other sites in York

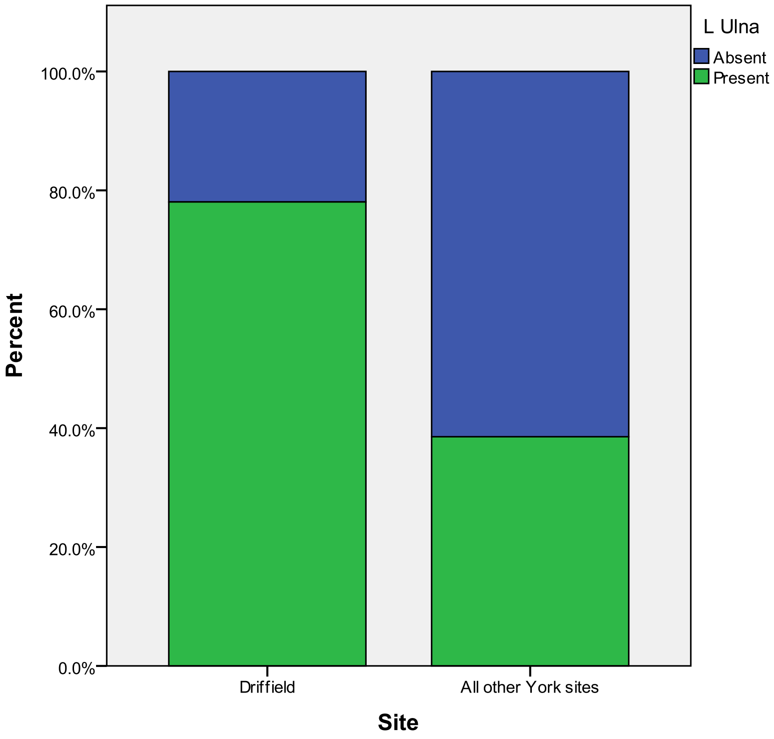


Figure A24: Proportional bar graph illustrating proportional preservation of the left ulna at Driffield Terrace vs. all other sites in York

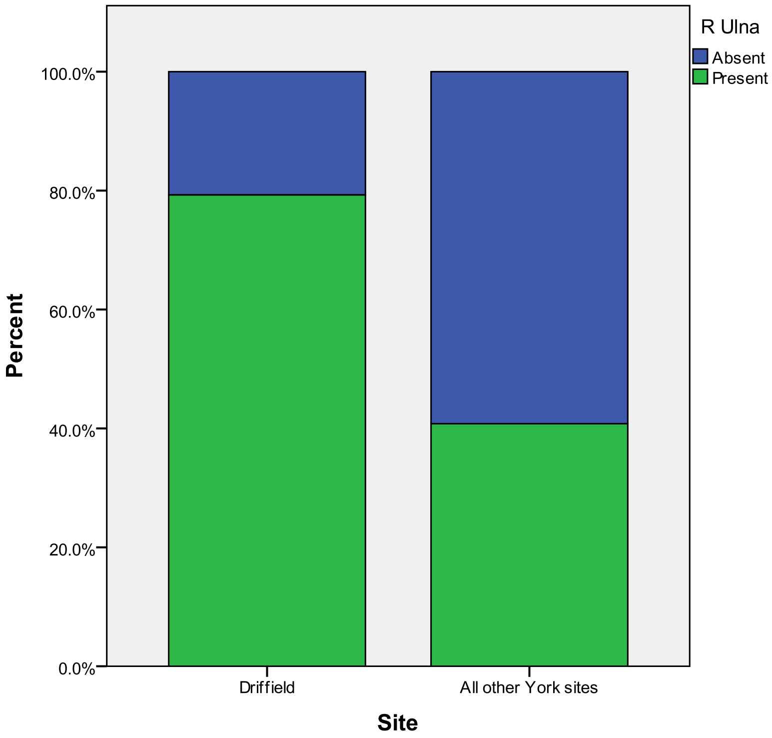


Figure A25: Proportional bar graph illustrating proportional preservation of the right ulna at Driffield Terrace vs. all other sites in York

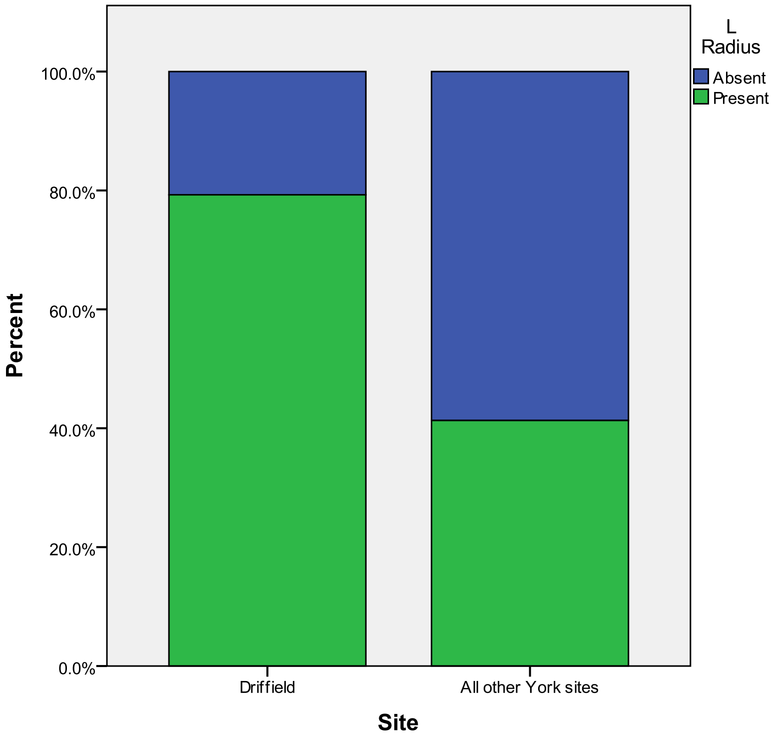


Figure A26: Proportional bar graph illustrating proportional preservation of the left radius at Driffield Terrace vs. all other sites in York

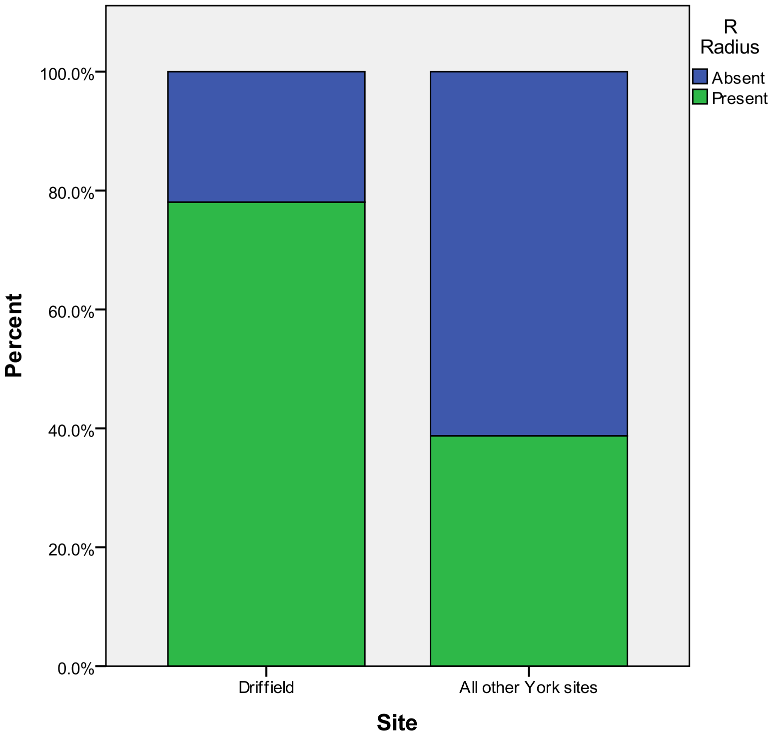


Figure A27: Proportional bar graph illustrating proportional preservation of the right radius at Driffield Terrace vs. all other sites in York

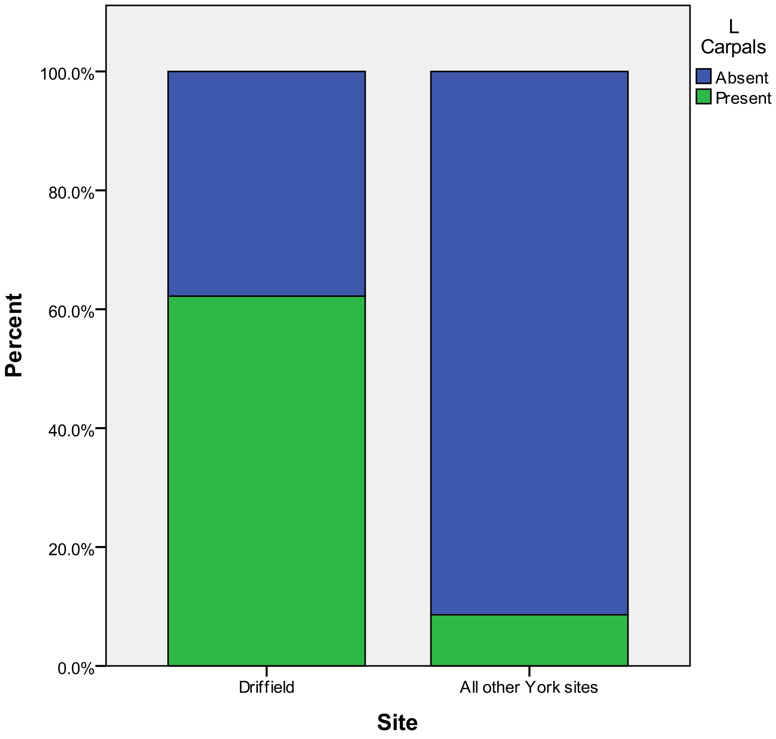


Figure A28: Proportional bar graph illustrating proportional preservation of the left carpals at Driffield Terrace vs. all other sites in York

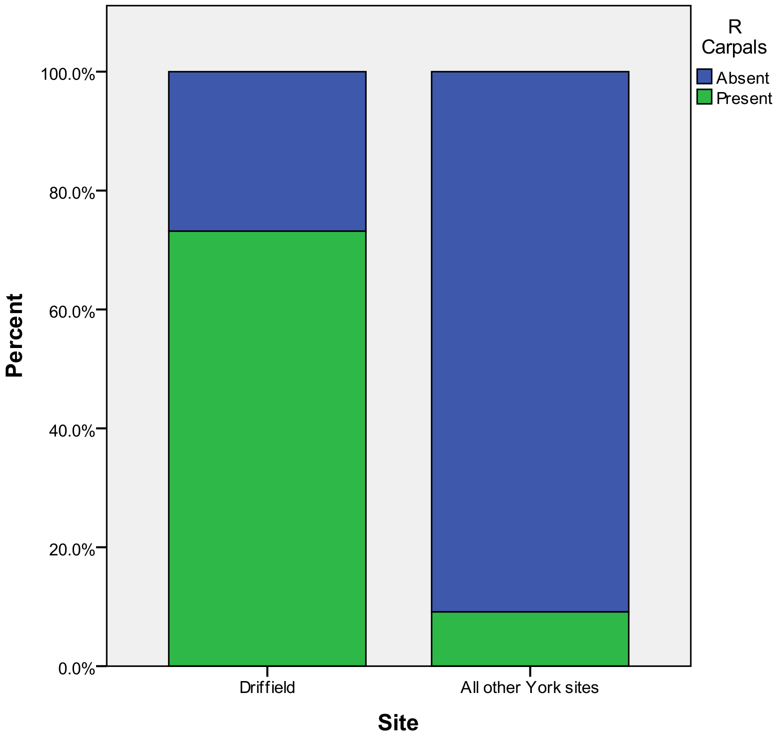


Figure A29: Proportional bar graph illustrating proportional preservation of the right carpals at Driffield Terrace vs. all other sites in York

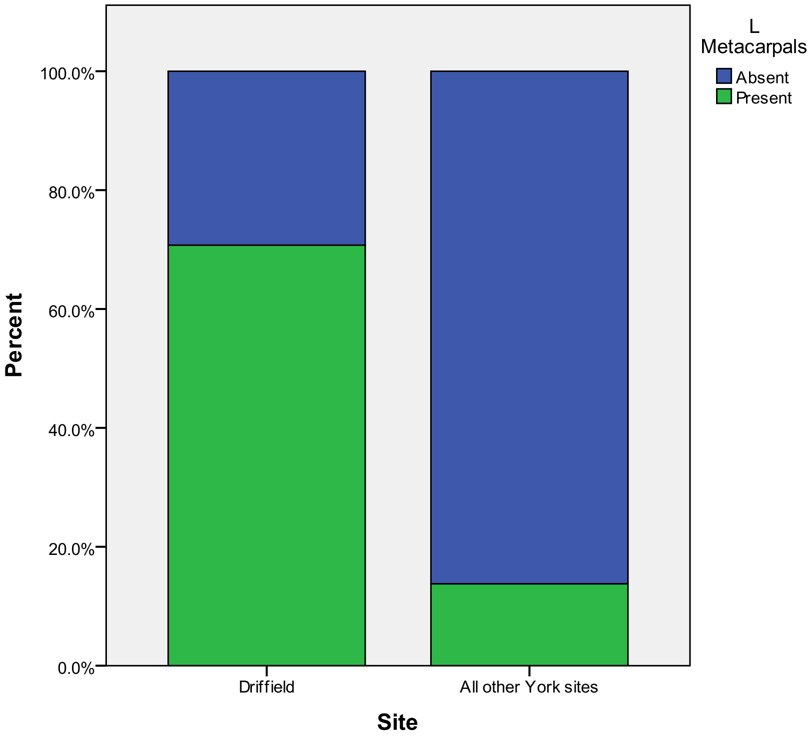


Figure A30: Proportional bar graph illustrating proportional preservation of the left metacarpals at Driffield Terrace vs. all other sites in York

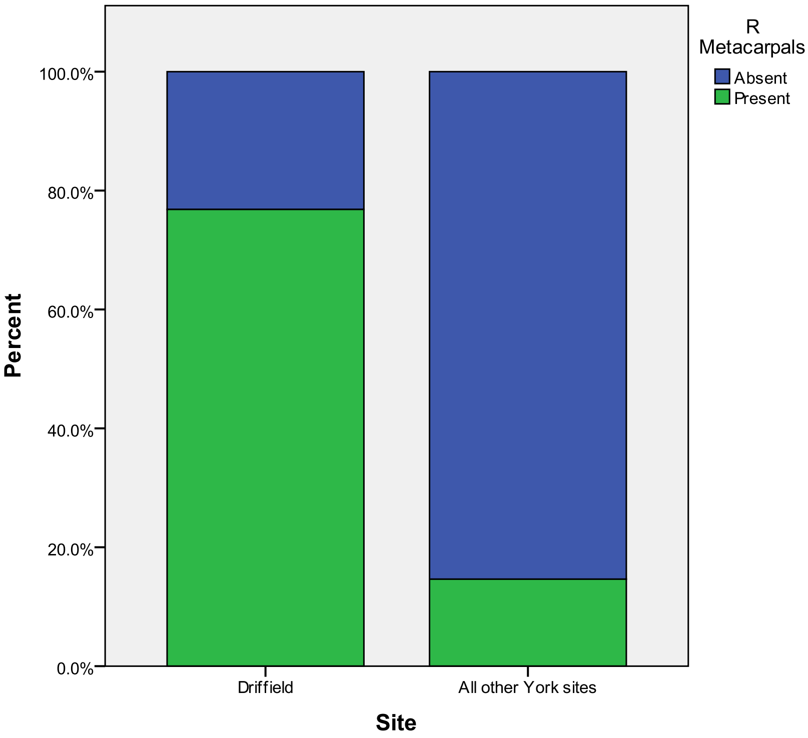


Figure A31: Proportional bar graph illustrating proportional preservation of the right metacarpals at Driffield Terrace vs. all other sites in York

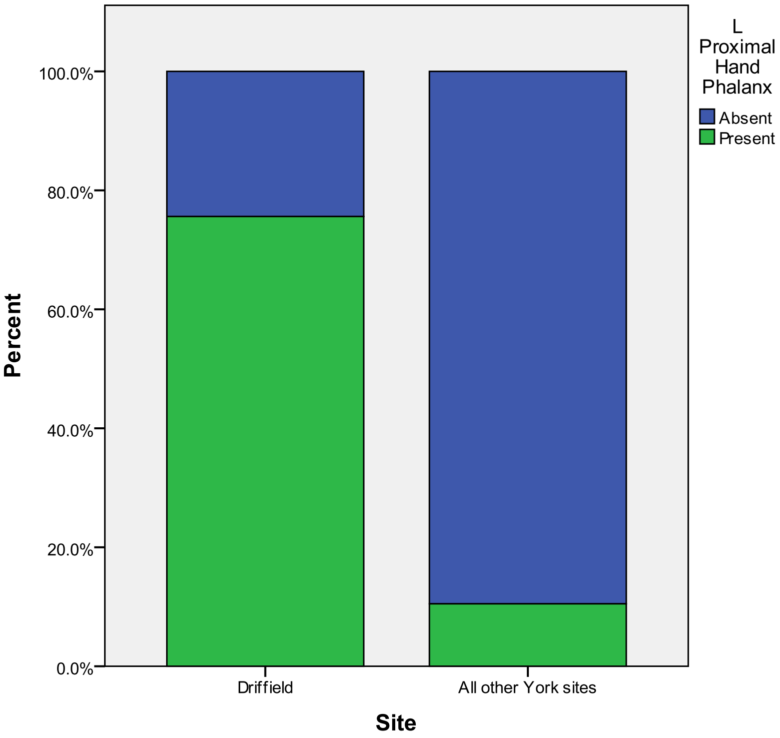


Figure A32: Proportional bar graph illustrating proportional preservation of the left proximal hand phalanges at Driffield Terrace vs. all other sites in York

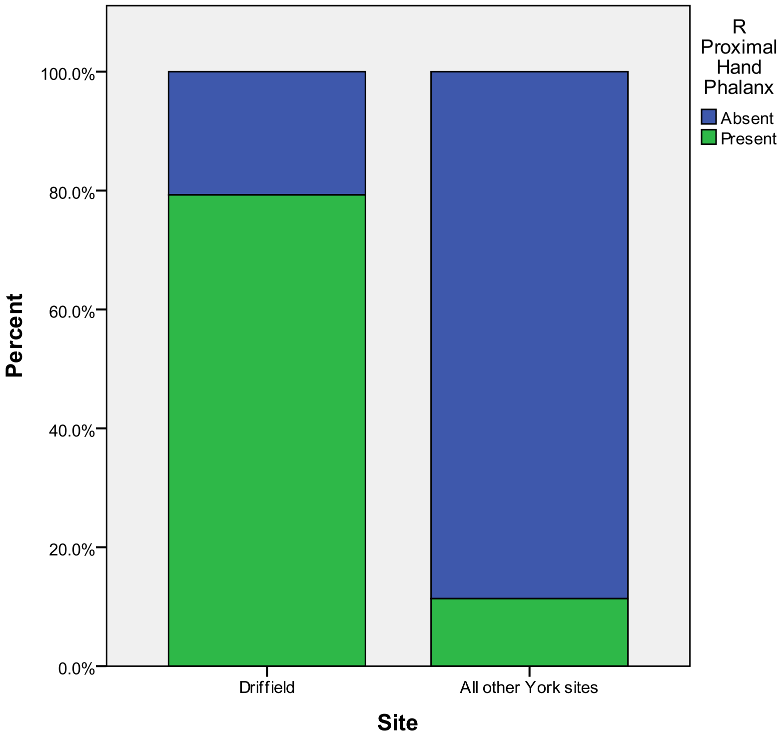


Figure A33: Proportional bar graph illustrating proportional preservation of the right proximal hand phalanges at Driffield Terrace vs. all other sites in York

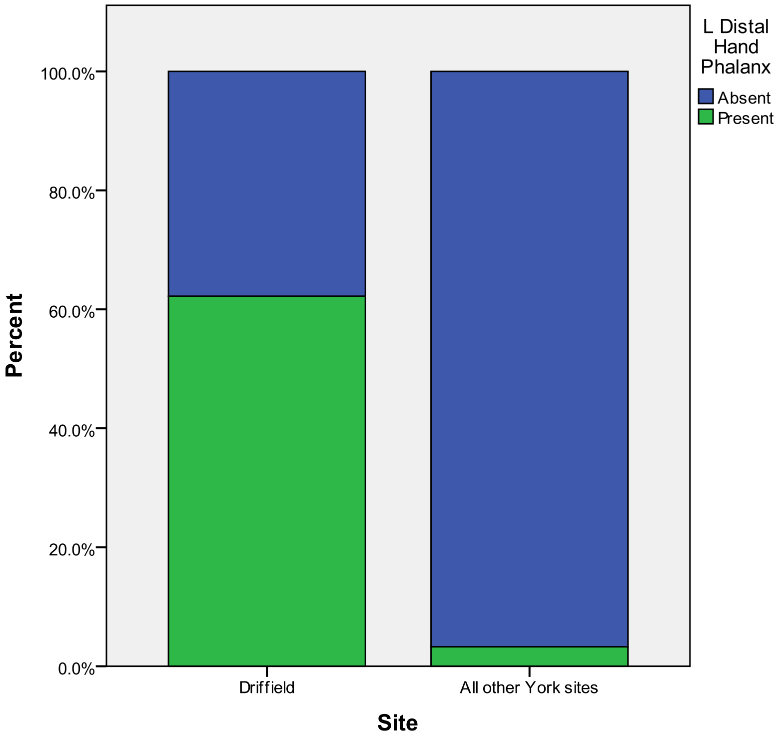


Figure A34: Proportional bar graph illustrating proportional preservation of the left distal hand phalanges at Driffield Terrace vs. all other sites in York

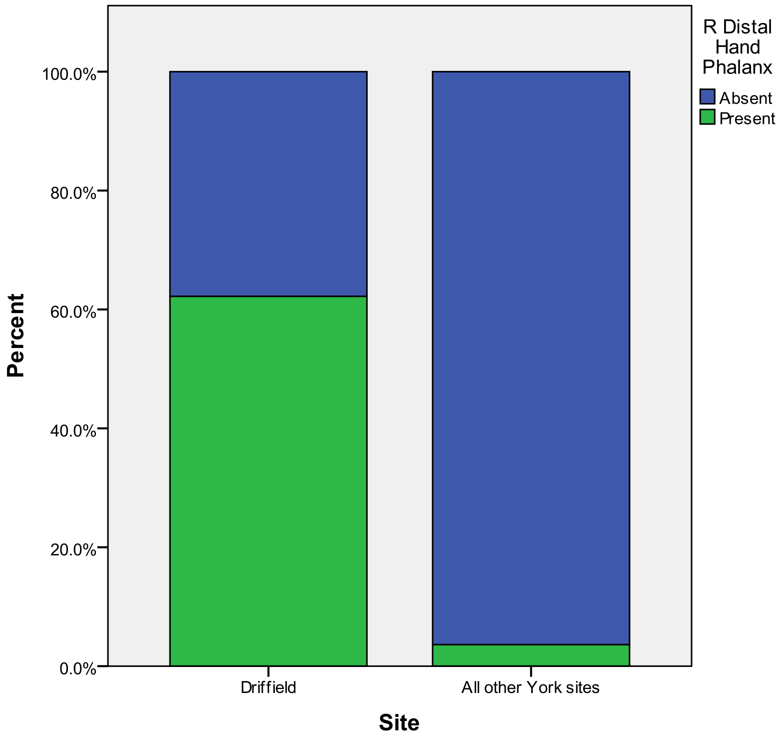


Figure A35: Proportional bar graph illustrating proportional preservation of the right distal hand phalanges at Driffield Terrace vs. all other sites in York

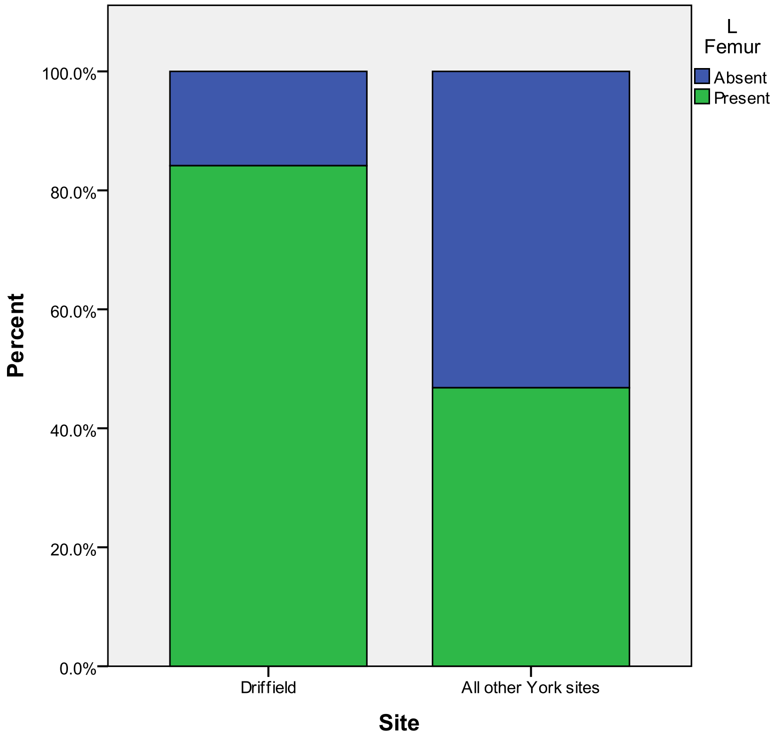


Figure A36: Proportional bar graph illustrating proportional preservation of the left femur at Driffield Terrace vs. all other sites in York

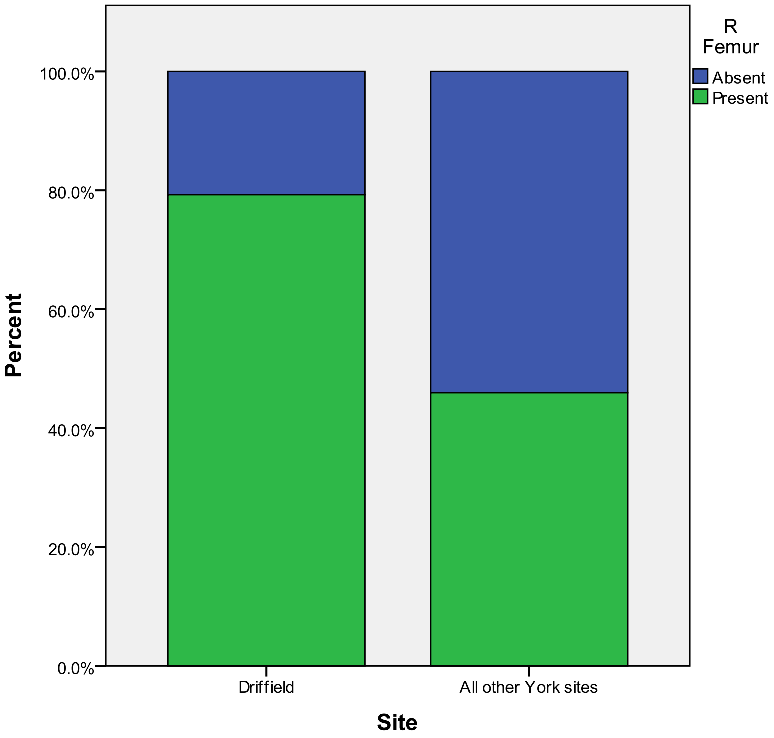


Figure A37: Proportional bar graph illustrating proportional preservation of the right femur at Driffield Terrace vs. all other sites in York

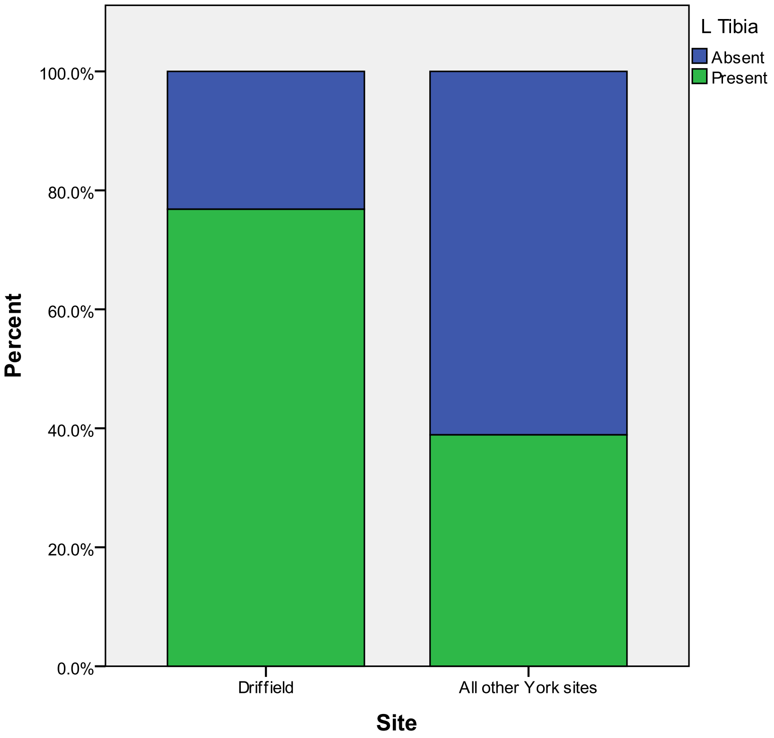


Figure A38: Proportional bar graph illustrating proportional preservation of the left tibia at Driffield Terrace vs. all other sites in York

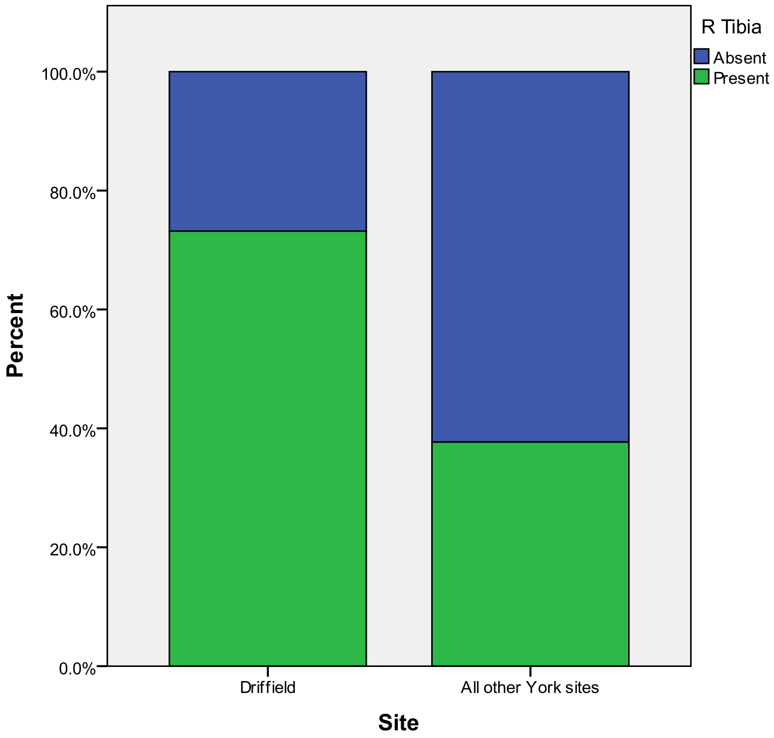


Figure A39: Proportional bar graph illustrating proportional preservation of the right tibia at Driffield Terrace vs. all other sites in York

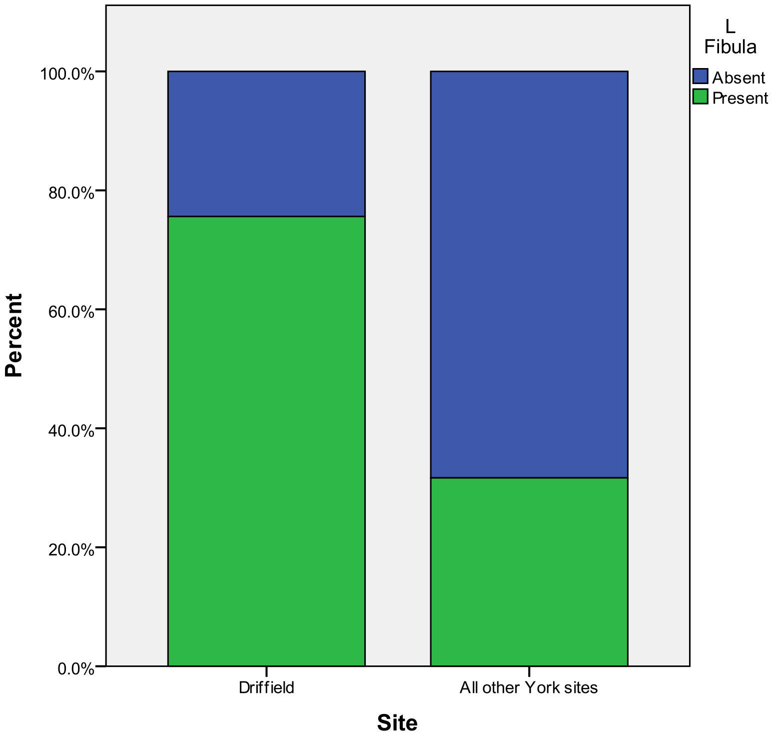


Figure A40: Proportional bar graph illustrating proportional preservation of the left fibula at Driffield Terrace vs. all other sites in York

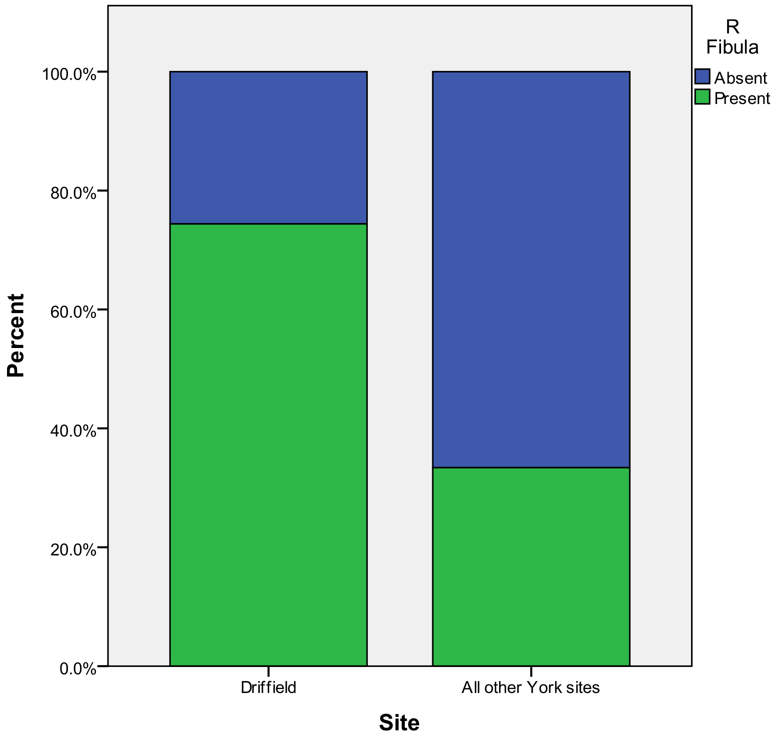


Figure A41: Proportional bar graph illustrating proportional preservation of the right fibula at Driffield Terrace vs. all other sites in York

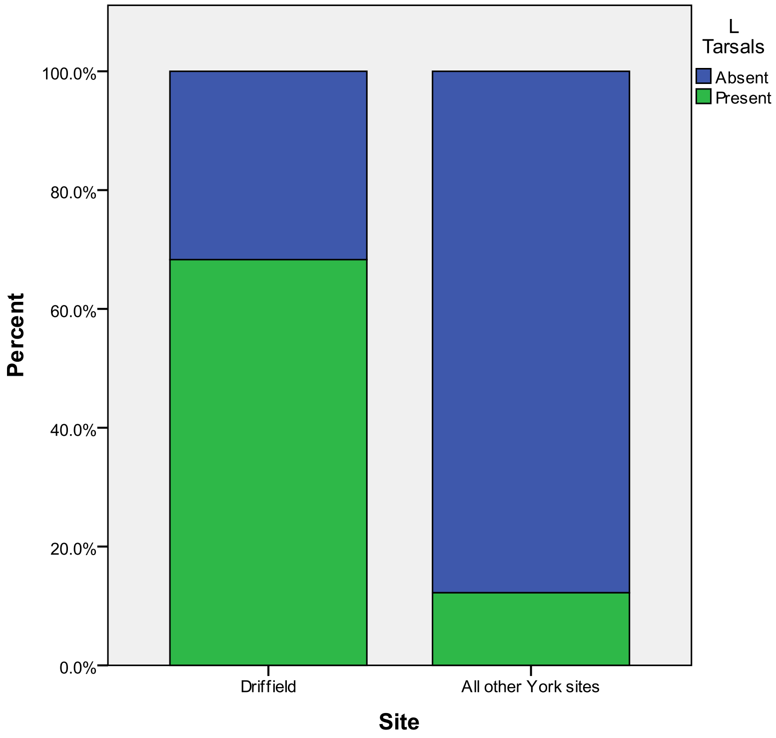


Figure A42: Proportional bar graph illustrating proportional preservation of the left tarsal bones at Driffield Terrace vs. all other sites in York

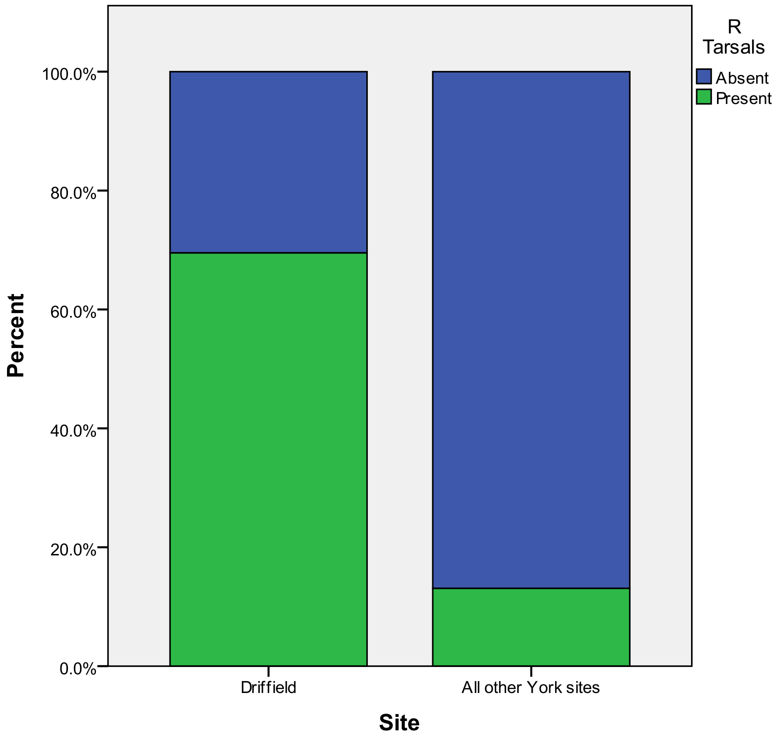


Figure A43: Proportional bar graph illustrating proportional preservation of the right tarsal bones at Driffield Terrace vs. all other sites in York

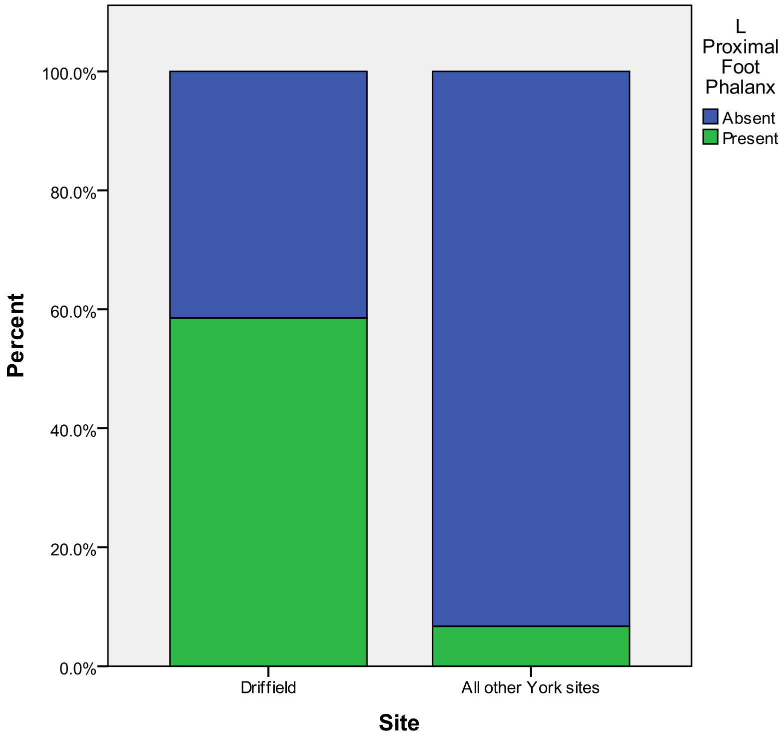


Figure A44: Proportional bar graph illustrating proportional preservation of the left proximal foot phalanges at Driffield Terrace vs. all other sites in York

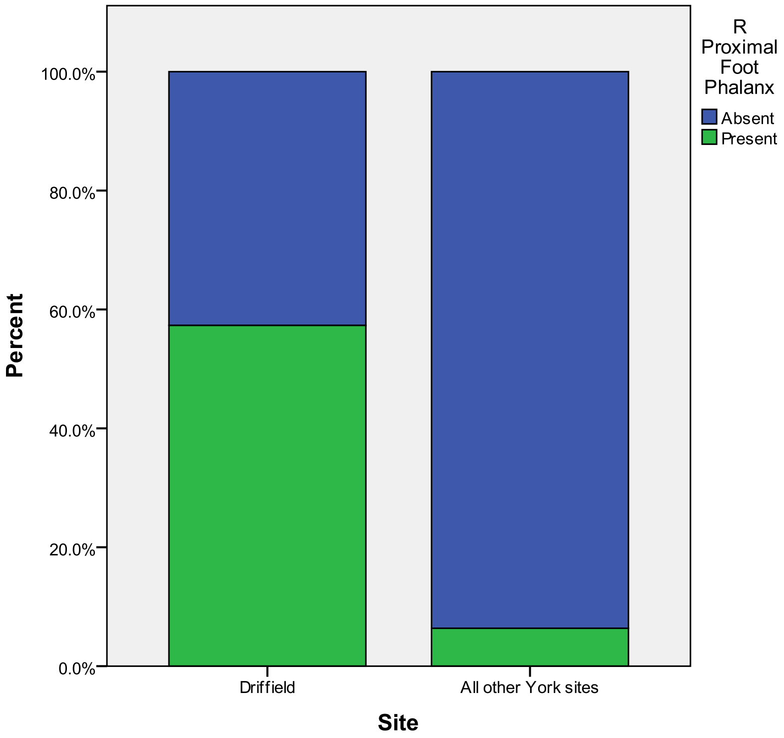


Figure A45: Proportional bar graph illustrating proportional preservation of the right proximal foot phalanges at Driffield Terrace vs. all other sites in York

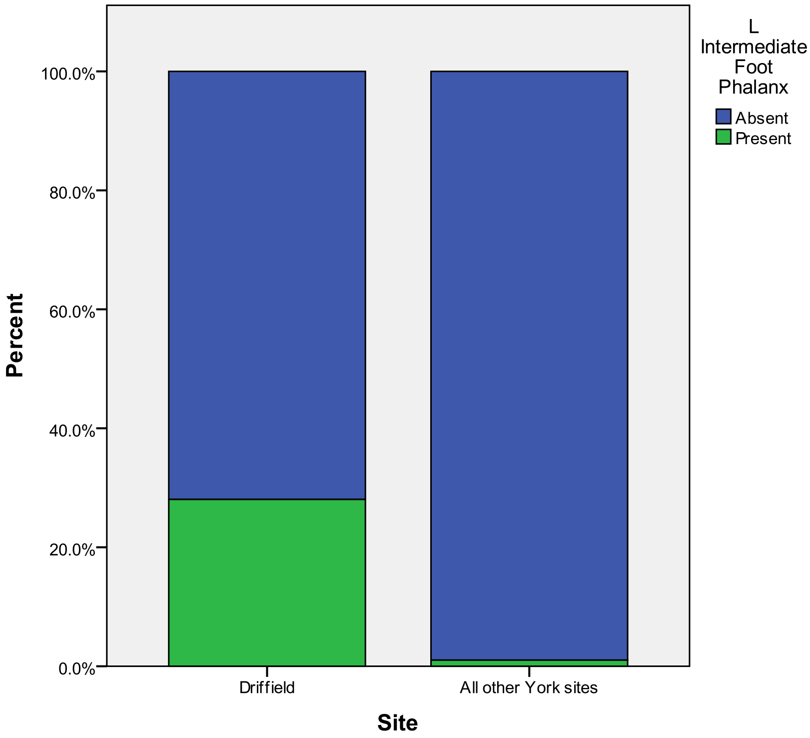


Figure A46: Proportional bar graph illustrating proportional preservation of the left intermediate foot phalanges at Driffield Terrace vs. all other sites in York

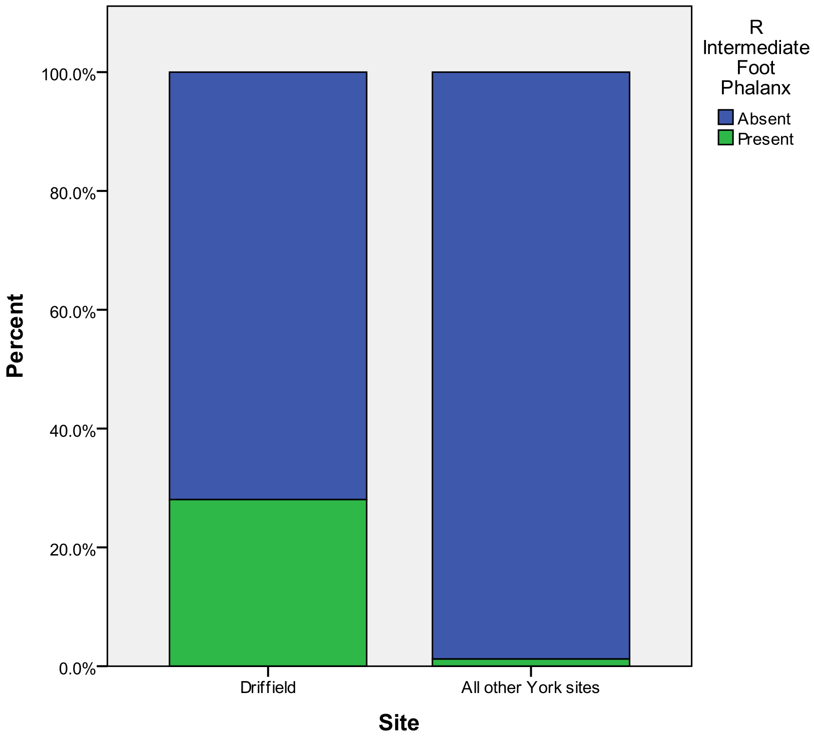


Figure A47: Proportional bar graph illustrating proportional preservation of the right intermediate foot phalanges at Driffield Terrace vs. all other sites in York

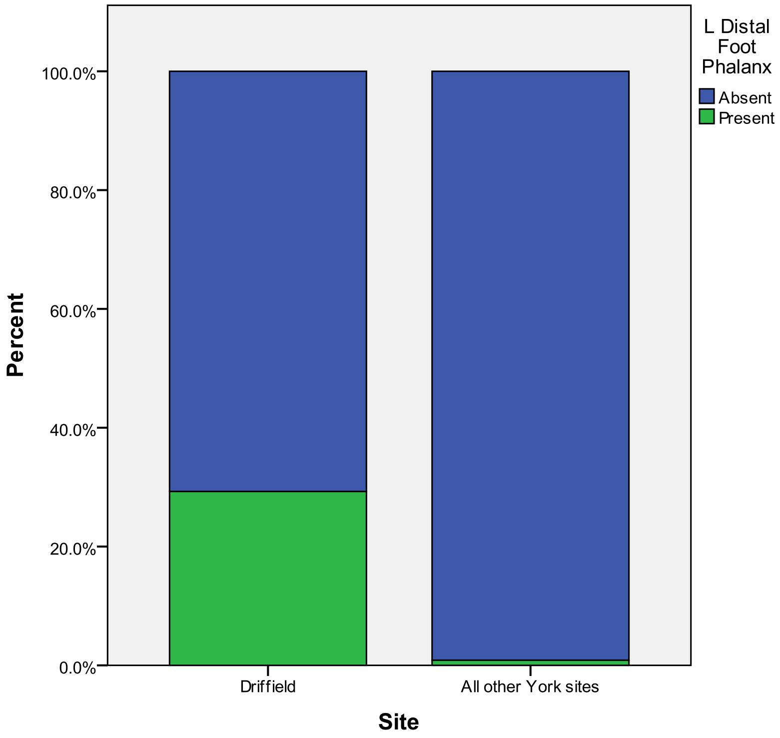


Figure A48: Proportional bar graph illustrating proportional preservation of the left distal foot phalanges at Driffield Terrace vs. all other sites in York

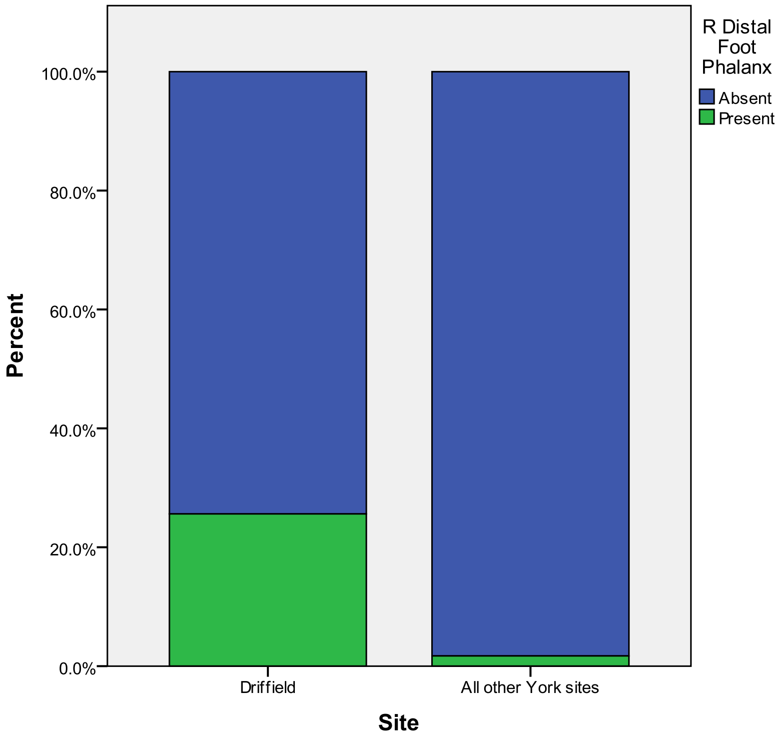
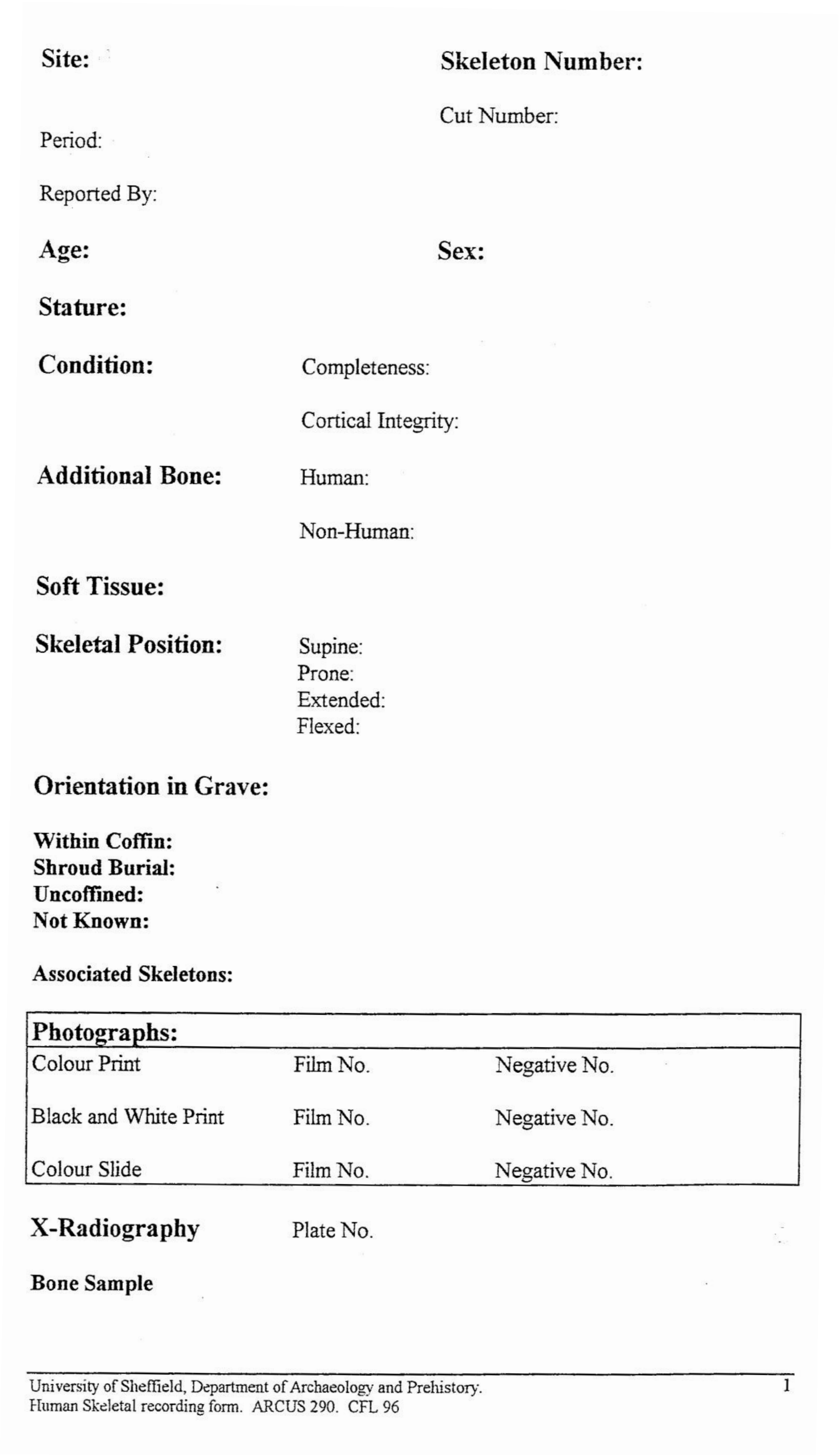


Figure A49: Proportional bar graph illustrating proportional preservation of the right distal foot phalanges at Driffield Terrace vs. all other sites in York

Appendix 5: University of Sheffield Pro Forma Recording Sheets



Site:

Skeleton Number:

Cut Number:

Period:

Reported By:

Age:

Sex:

Stature:

Condition:

Completeness:

Cortical Integrity:

Additional Bone:

Human:

Non-Human:

Soft Tissue:

Skeletal Position:

Supine:
Prone:
Extended:
Flexed:

Orientation in Grave:

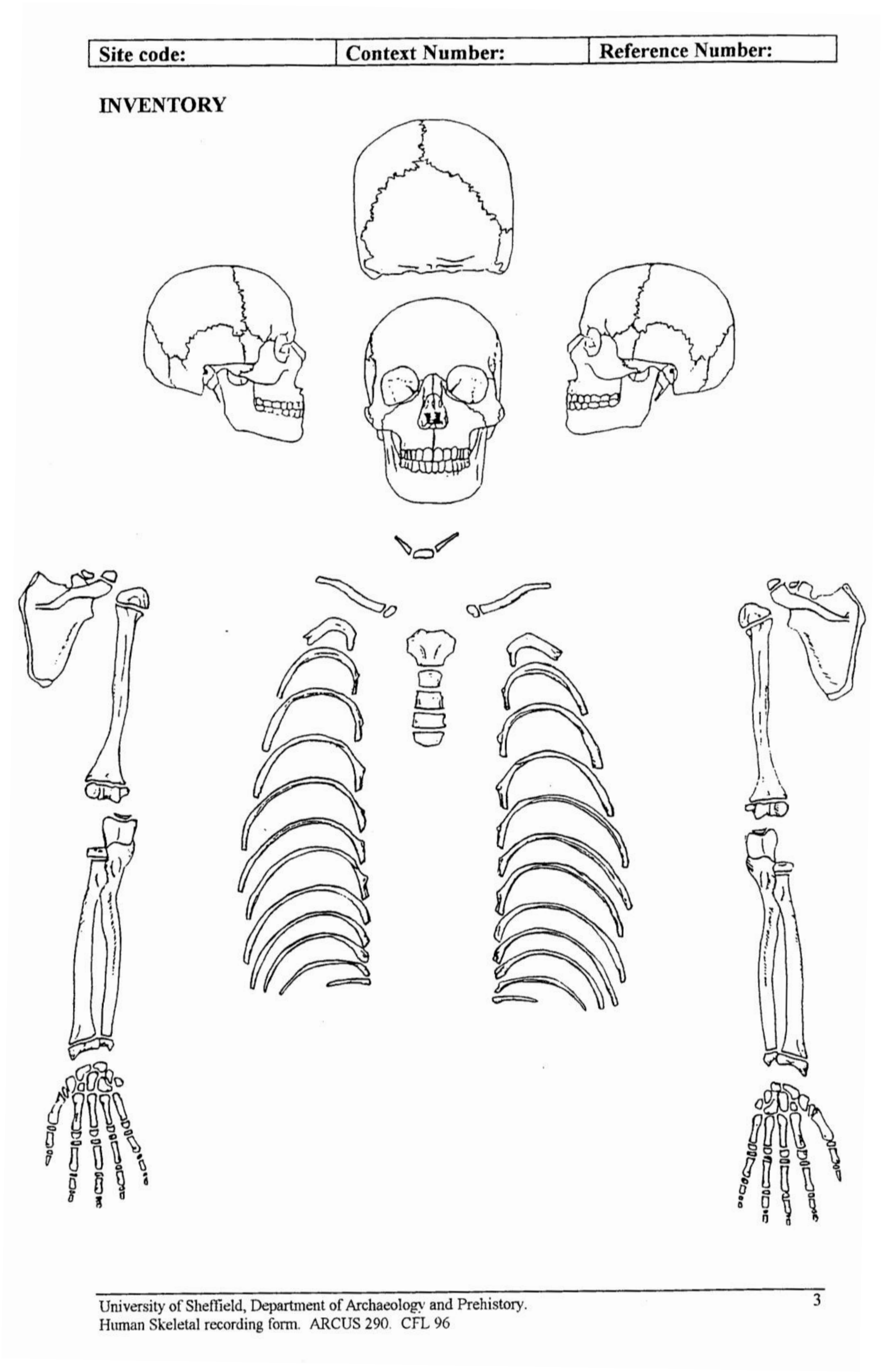
Within Coffin:
Shroud Burial:
Uncoffined:
Not Known:

Associated Skeletons:

Photographs:		
Colour Print	Film No.	Negative No.
Black and White Print	Film No.	Negative No.
Colour Slide	Film No.	Negative No.

X-Radiography Plate No.

Bone Sample



Site code:	**Context Number:**	**Reference Number:**

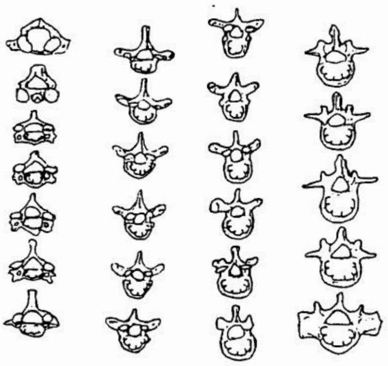
INVENTORY

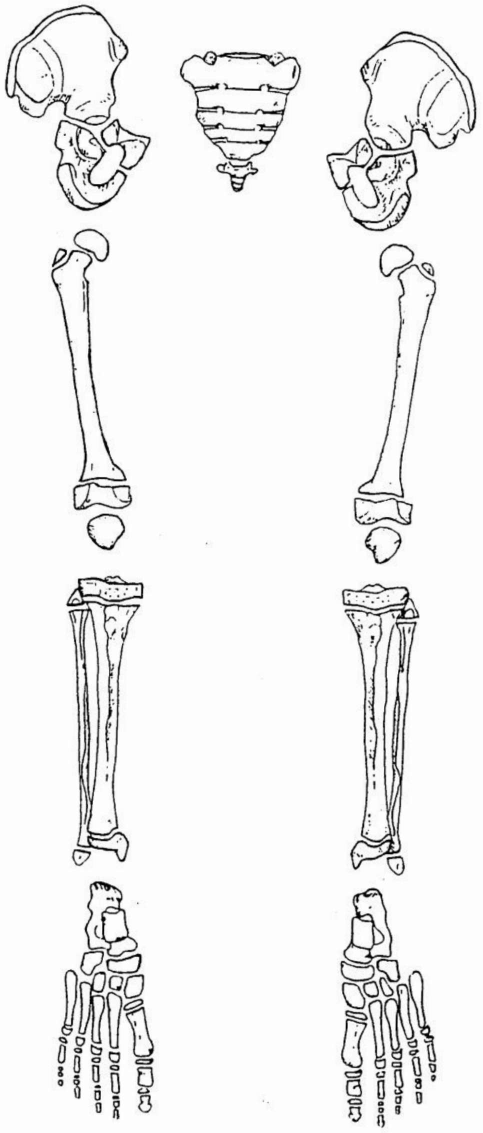
University of Sheffield, Department of Archaeology and Prehistory.
Human Skeletal recording form. ARCUS 290. CFL 96

3

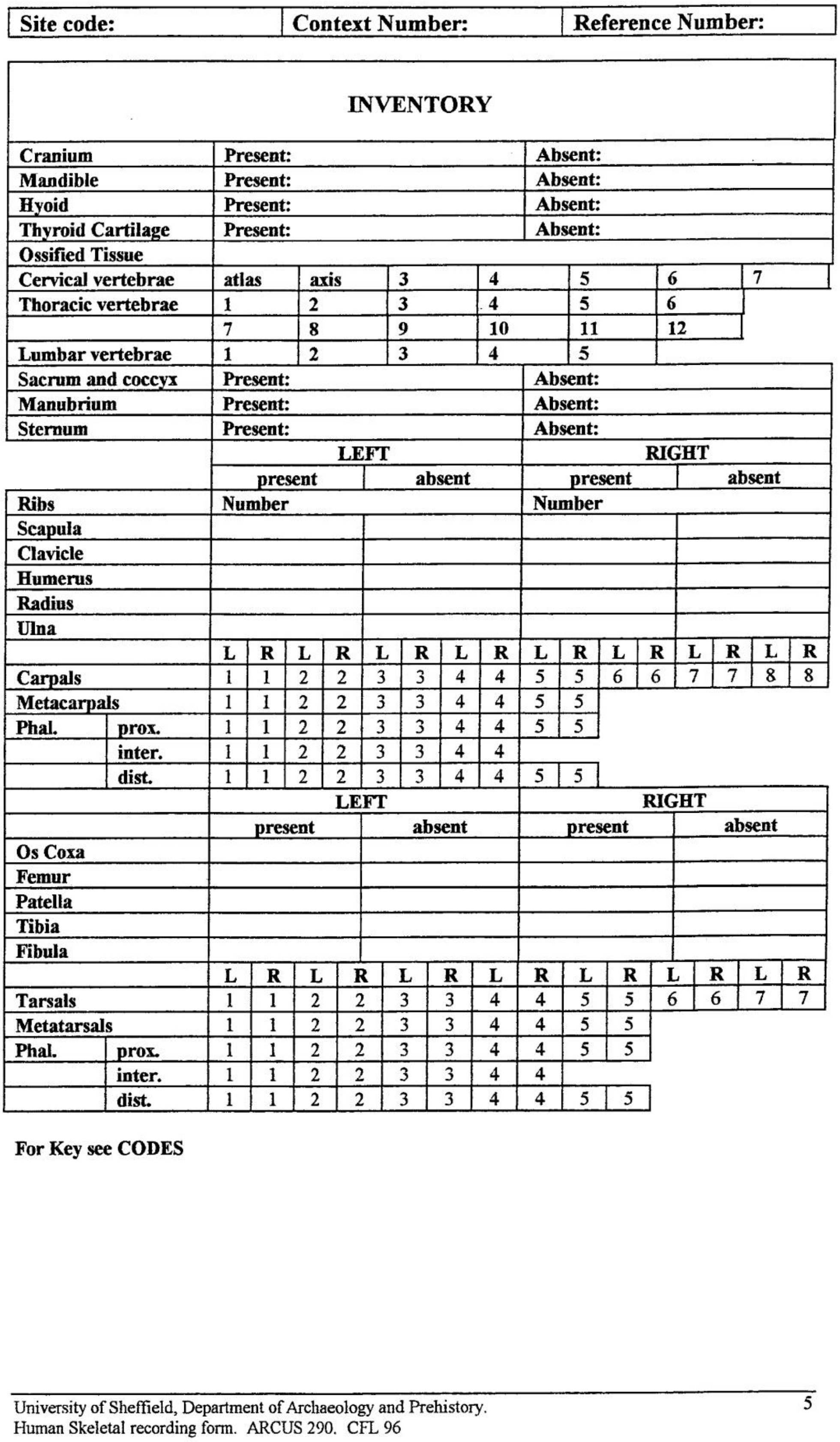
Site code:	**Context Number:**	**Reference Number:**

INVENTORY





FRAGMENTS



Site code:	**Context Number:**	**Reference Number:**

INVENTORY

Cranium	**Present:**	**Absent:**
Mandible	**Present:**	**Absent:**
Hyoid	**Present:**	**Absent:**
Thyroid Cartilage	**Present:**	**Absent:**
Ossified Tissue		

Cervical vertebrae	**atlas**	**axis**	**3**	**4**	**5**	**6**	**7**
Thoracic vertebrae	**1**	**2**	**3**	**4**	**5**	**6**	
	7	**8**	**9**	**10**	**11**	**12**	
Lumbar vertebrae	**1**	**2**	**3**	**4**	**5**		

Sacrum and coccyx	**Present:**	**Absent:**
Manubrium	**Present:**	**Absent:**
Sternum	**Present:**	**Absent:**

	LEFT		**RIGHT**	
	present	**absent**	**present**	**absent**
Ribs	**Number**		**Number**	
Scapula				
Clavicle				
Humerus				
Radius				
Ulna				

		L	**R**	**L**	**R**	**L**	**R**	**L**	**R**	**L**	**R**	**L**	**R**	**L**	**R**	**L**	**R**
Carpals		1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8
Metacarpals		1	1	2	2	3	3	4	4	5	5						
Phal.	**prox.**	1	1	2	2	3	3	4	4	5	5						
	inter.	1	1	2	2	3	3	4	4								
	dist.	1	1	2	2	3	3	4	4	5	5						

	LEFT		**RIGHT**	
	present	**absent**	**present**	**absent**
Os Coxa				
Femur				
Patella				
Tibia				
Fibula				

		L	**R**	**L**	**R**	**L**	**R**	**L**	**R**	**L**	**R**	**L**	**R**	**L**	**R**
Tarsals		1	1	2	2	3	3	4	4	5	5	6	6	7	7
Metatarsals		1	1	2	2	3	3	4	4	5	5				
Phal.	**prox.**	1	1	2	2	3	3	4	4	5	5				
	inter.	1	1	2	2	3	3	4	4						
	dist.	1	1	2	2	3	3	4	4	5	5				

For Key see CODES

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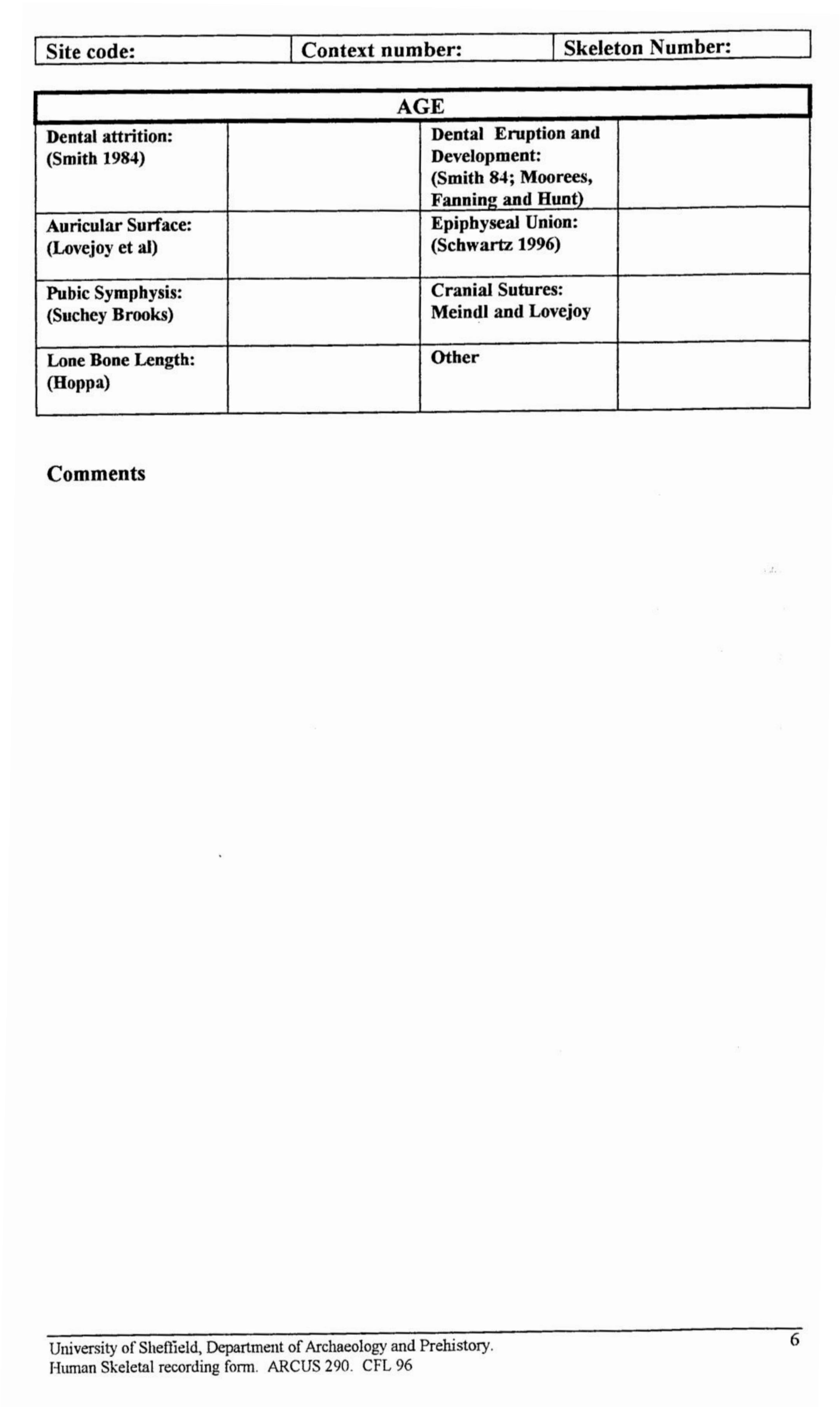
Human Skeletal recording form. ARCUS 290. CFL 96



Site code:	**Context number:**	**Skeleton Number:**

AGE			
Dental attrition: **(Smith 1984)**		**Dental Eruption and Development:** **(Smith 84; Moorees, Fanning and Hunt)**	
Auricular Surface: **(Lovejoy et al)**		**Epiphyseal Union:** **(Schwartz 1996)**	
Pubic Symphysis: **(Suchey Brooks)**		**Cranial Sutures:** **Meindl and Lovejoy**	
Lone Bone Length: **(Hoppa)**		**Other**	

Comments

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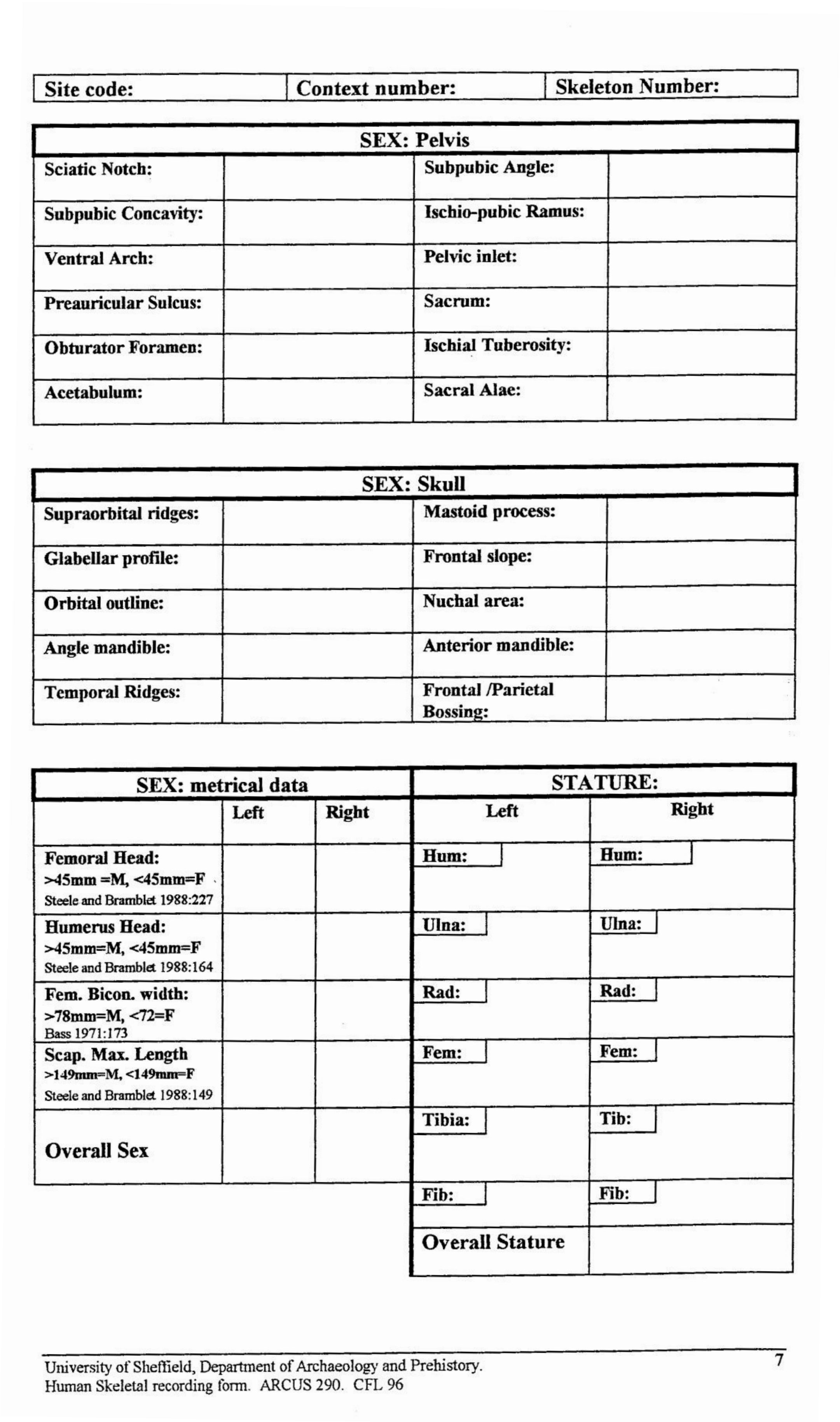
Human Skeletal recording form. ARCUS 290. CFL 96



Site code:	**Context number:**	**Skeleton Number:**

SEX: Pelvis			
Sciatic Notch:		**Subpubic Angle:**	
Subpubic Concavity:		**Ischio-pubic Ramus:**	
Ventral Arch:		**Pelvic inlet:**	
Preauricular Sulcus:		**Sacrum:**	
Obturator Foramen:		**Ischial Tuberosity:**	
Acetabulum:		**Sacral Alae:**	

SEX: Skull			
Supraorbital ridges:		**Mastoid process:**	
Glabellar profile:		**Frontal slope:**	
Orbital outline:		**Nuchal area:**	
Angle mandible:		**Anterior mandible:**	
Temporal Ridges:		**Frontal /Parietal Bossing:**	

SEX: metrical data		
	Left	**Right**
Femoral Head: **>45mm =M, <45mm=F** Steele and Bramblet 1988:227		
Humerus Head: **>45mm=M, <45mm=F** Steele and Bramblet 1988:164		
Fem. Bicon. width: **>78mm=M, <72=F** Bass 1971:173		
Scap. Max. Length **>149mm=M, <149mm=F** Steele and Bramblet 1988:149		
Overall Sex		

STATURE:	
Left	**Right**
Hum:	**Hum:**
Ulna:	**Ulna:**
Rad:	**Rad:**
Fem:	**Fem:**
Tibia:	**Tib:**
Fib:	**Fib:**
Overall Stature	

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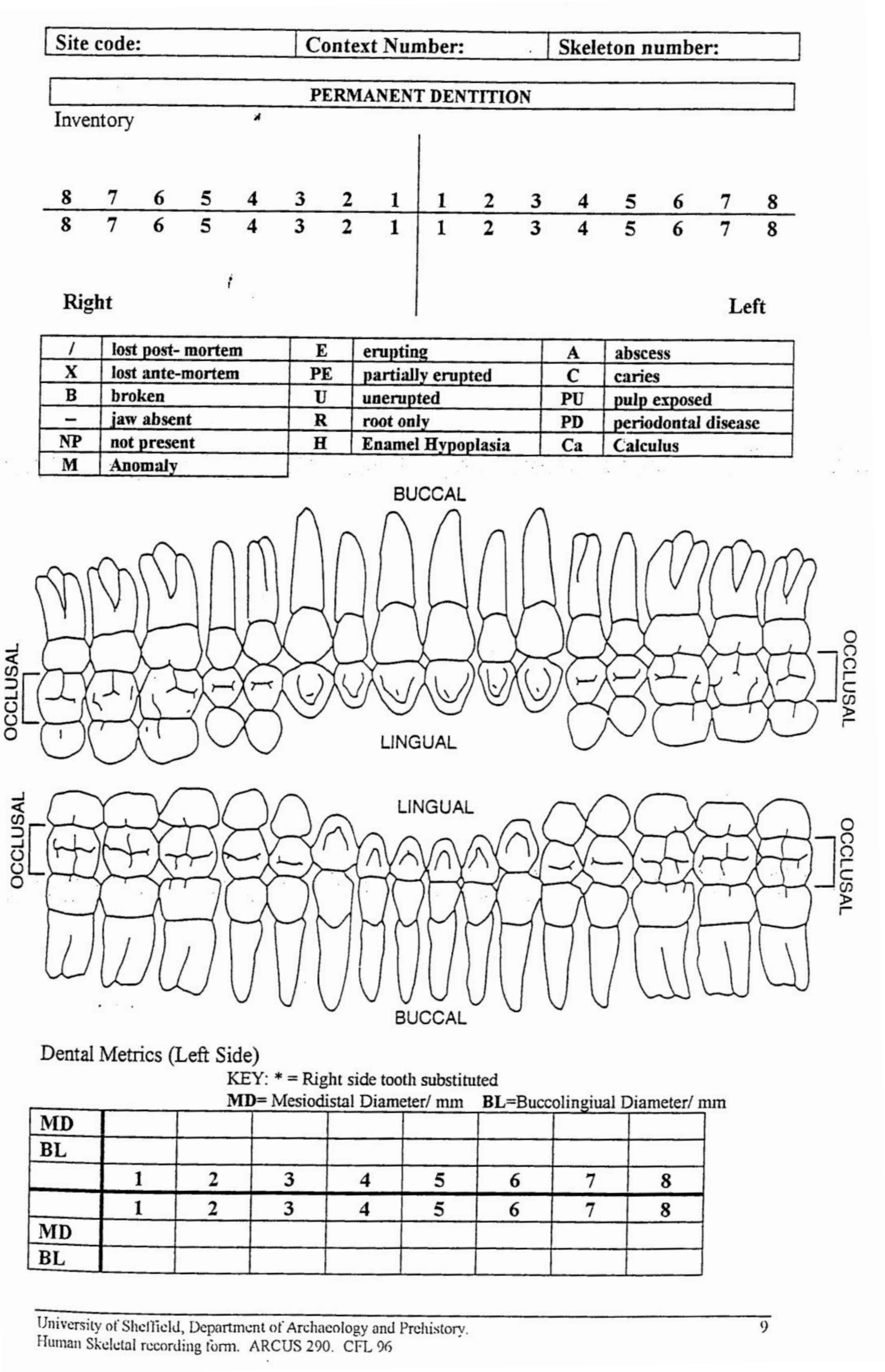

Site code:	Context Number:	Skeleton number:

PERMANENT DENTITION

Inventory

8	7	6	5	4	3	2	1	1	2	3	4	5	6	7	8
8	7	6	5	4	3	2	1	1	2	3	4	5	6	7	8

Right **Left**

/	**lost post- mortem**	**E**	**erupting**	**A**	**abscess**
X	**lost ante-mortem**	**PE**	**partially erupted**	**C**	**caries**
B	**broken**	**U**	**unerupted**	**PU**	**pulp exposed**
–	**jaw absent**	**R**	**root only**	**PD**	**periodontal disease**
NP	**not present**	**H**	**Enamel Hypoplasia**	**Ca**	**Calculus**
M	**Anomaly**				

Dental Metrics (Left Side)

KEY: * = Right side tooth substituted

MD= Mesiodistal Diameter/ mm **BL**=Buccolingiual Diameter/ mm

MD								
BL								
	1	2	3	4	5	6	7	8
	1	2	3	4	5	6	7	8
MD								
BL								

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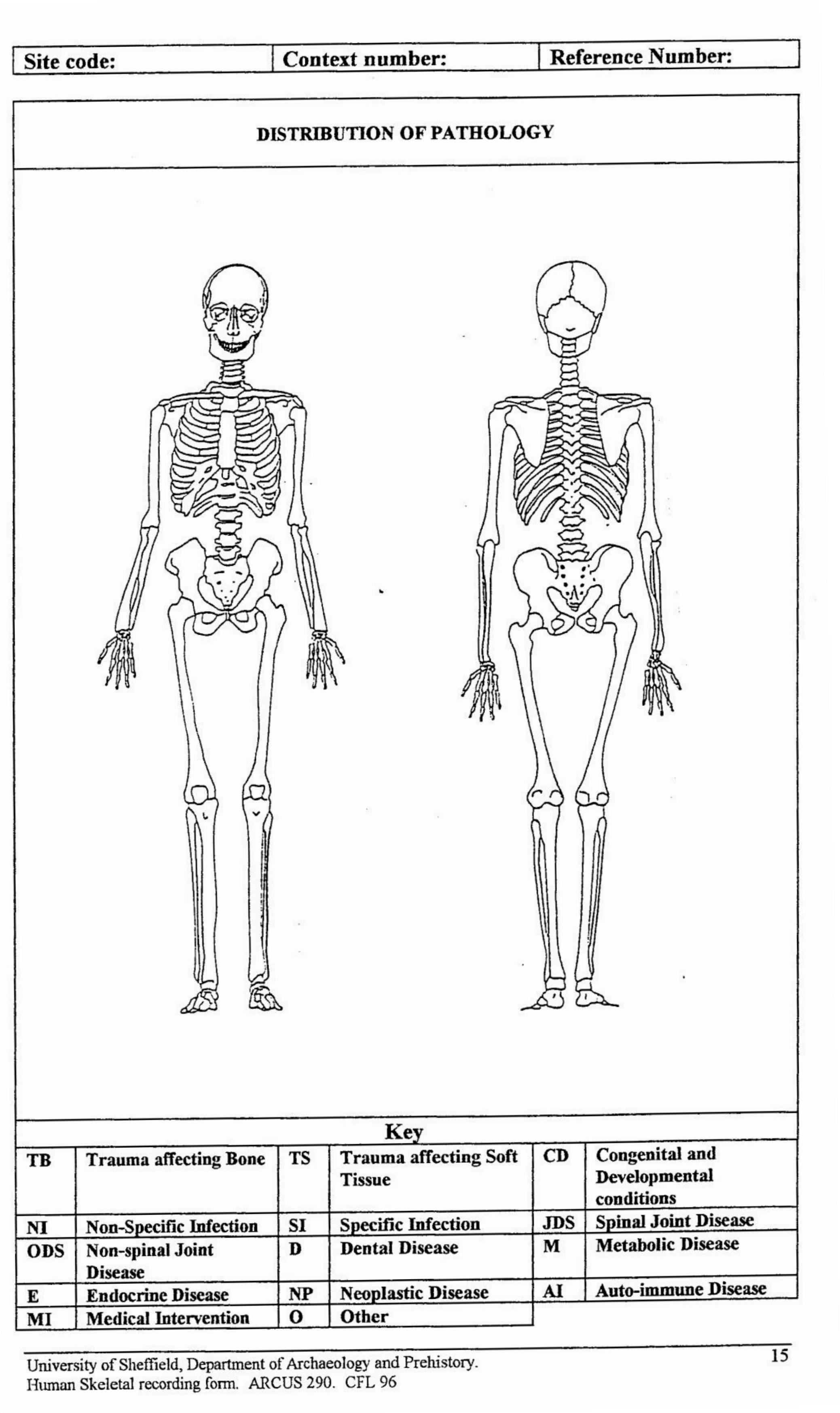
Human Skeletal recording form. ARCUS 290. CFL 96

Site code:	**Context number:**	**Skeleton Number:**

PATHOLOGY



Site code:	Context number:	Reference Number:

DISTRIBUTION OF PATHOLOGY

Key

TB	Trauma affecting Bone	TS	Trauma affecting Soft Tissue	CD	Congenital and Developmental conditions
NI	Non-Specific Infection	SI	Specific Infection	JDS	Spinal Joint Disease
ODS	Non-spinal Joint Disease	D	Dental Disease	M	Metabolic Disease
E	Endocrine Disease	NP	Neoplastic Disease	AI	Auto-immune Disease
MI	Medical Intervention	O	Other		

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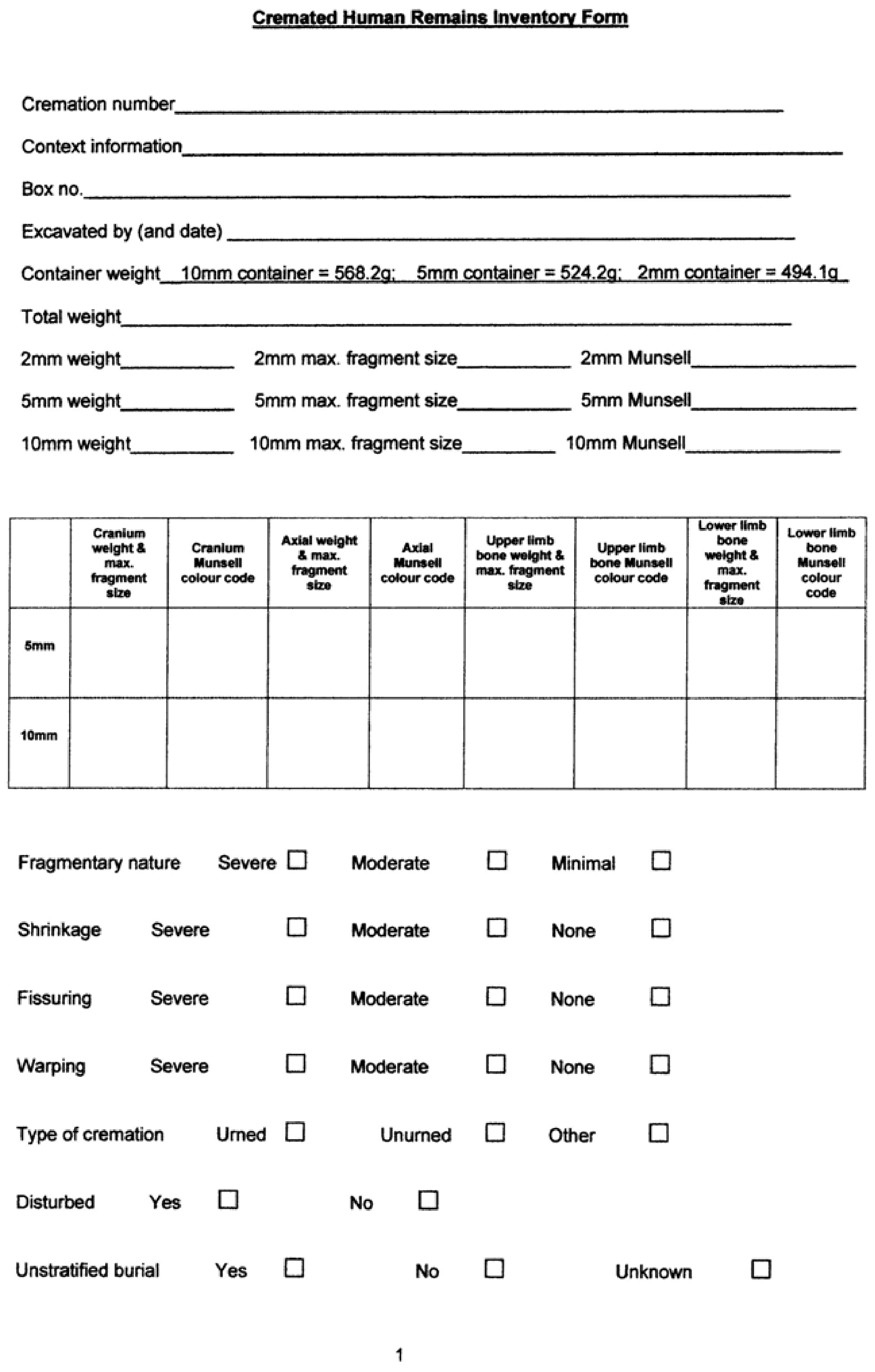


Cremated Human Remains Inventory Form

Cremation number____

Context information____

Box no.____

Excavated by (and date) ____

Container weight 10mm container = 568.2g; 5mm container = 524.2g; 2mm container = 494.1g

Total weight____

2mm weight__________ 2mm max. fragment size__________ 2mm Munsell______________

5mm weight__________ 5mm max. fragment size__________ 5mm Munsell______________

10mm weight__________ 10mm max. fragment size__________ 10mm Munsell______________

	Cranium weight & max. fragment size	Cranium Munsell colour code	Axial weight & max. fragment size	Axial Munsell colour code	Upper limb bone weight & max. fragment size	Upper limb bone Munsell colour code	Lower limb bone weight & max. fragment size	Lower limb bone Munsell colour code
5mm								
10mm								

Fragmentary nature Severe ☐ Moderate ☐ Minimal ☐

Shrinkage Severe ☐ Moderate ☐ None ☐

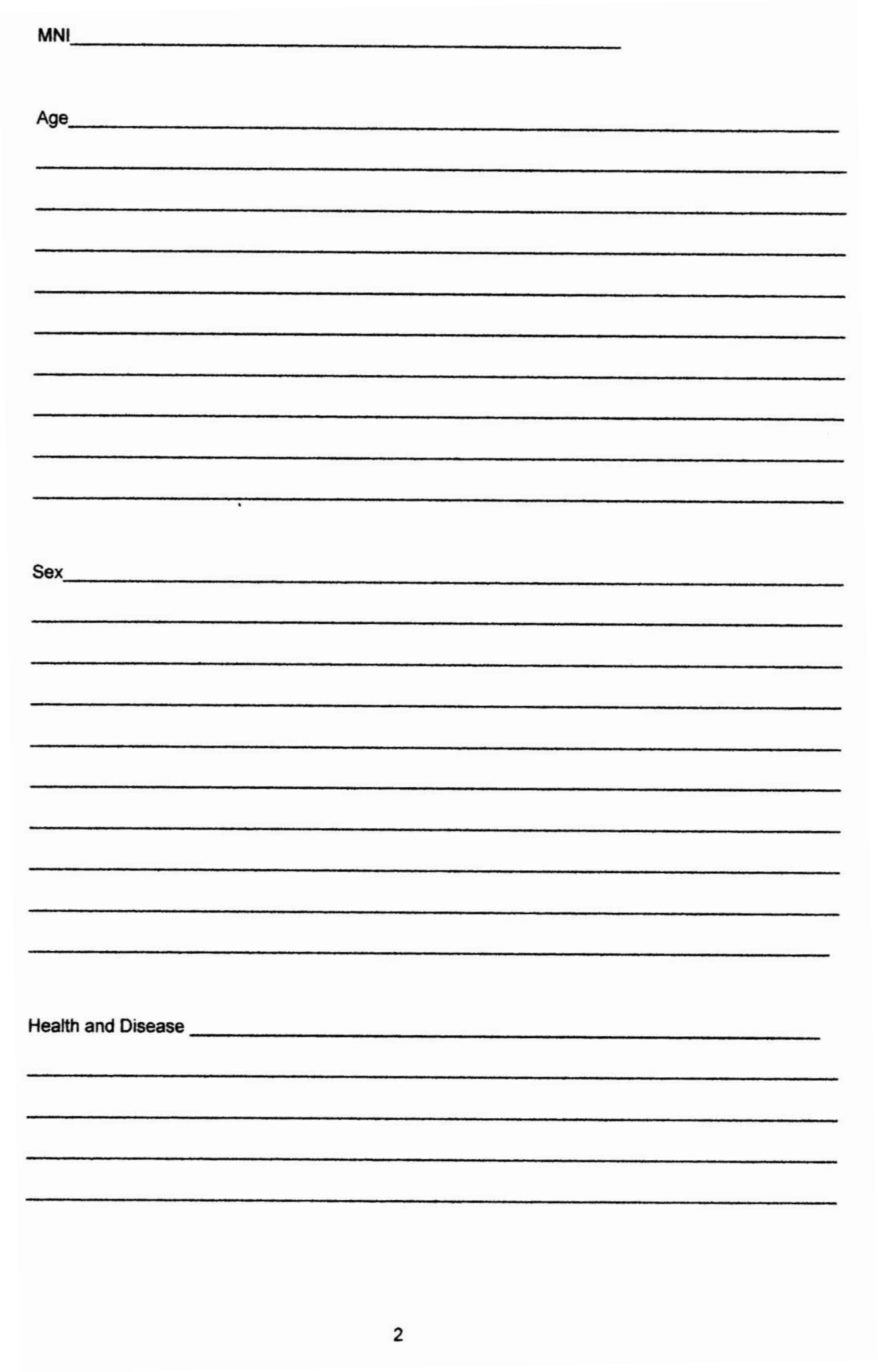
Fissuring Severe ☐ Moderate ☐ None ☐

Warping Severe ☐ Moderate ☐ None ☐

Type of cremation Urned ☐ Unurned ☐ Other ☐

Disturbed Yes ☐ No ☐

Unstratified burial Yes ☐ No ☐ Unknown ☐



MNI____________________

Age____________________

Sex____________________

Health and Disease ____________________

Animal remains ____

____

____

Pyre debris ____

____

____

Pyre goods ____

____

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Photographs ____

____

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Other notes ____

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Skeletal completeness

Cranium ☐

Clavicle ☐

Sternum ☐

Vertebrae ☐

Sacrum ☐

Radius ☐

Femur ☐

Fibula ☐

Tarsals ☐

Metatarsals ☐

Phalanges (foot) ☐

Hyoid ☐

Teeth ☐

Scapula ☐

Ribs ☐

Os Coxa ☐

Humerus ☐

Ulna ☐

Tibia ☐

Patella ☐

Carpals ☐

Metacarpals ☐

Phalanges (hand) ☐

Auditory ossicles ☐

Elements present <25% ☐ 25-75% ☐ >75% ☐

Skeletal completeness (2mm)

Cranium ☐

Clavicle ☐

Sternum ☐

Vertebrae ☐

Sacrum ☐

Radius ☐

Femur ☐

Fibula ☐

Tarsals ☐

Metatarsals ☐

Phalanges (foot) ☐

Hyoid ☐

Teeth ☐

Scapula ☐

Ribs ☐

Os Coxa ☐

Humerus ☐

Ulna ☐

Tibia ☐

Patella ☐

Carpals ☐

Metacarpals ☐

Phalanges (hand) ☐

Auditory ossicles ☐

Elements present <25% ☐ 25-75% ☐ >75% ☐

Skeletal completeness (5mm)

Cranium ☐
Clavicle ☐
Sternum ☐
Vertebrae ☐
Sacrum ☐
Radius ☐
Femur ☐
Fibula ☐
Tarsals ☐
Metatarsals ☐
Phalanges (foot) ☐
Hyoid ☐

Teeth ☐
Scapula ☐
Ribs ☐
Os Coxa ☐
Humerus ☐
Ulna ☐
Tibia ☐
Patella ☐
Carpals ☐
Metacarpals ☐
Phalanges (hand) ☐
Auditory ossicles ☐

Elements present <25% ☐ 25-75% ☐ >75% ☐

Skeletal completeness (10mm)

Cranium ☐

Clavicle ☐

Sternum ☐

Vertebrae ☐

Sacrum ☐

Radius ☐

Femur ☐

Fibula ☐

Tarsals ☐

Metatarsals ☐

Phalanges (foot) ☐

Hyoid ☐

Teeth ☐

Scapula ☐

Ribs ☐

Os Coxa ☐

Humerus ☐

Ulna ☐

Tibia ☐

Patella ☐

Carpals ☐

Metacarpals ☐

Phalanges (hand) ☐

Auditory ossicles ☐

Elements present <25% ☐ 25-75% ☐ >75% ☐