Skeletal Variation as a Possible Reflection of Relatedness within Three Medieval British Populations

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Abstract

Nonmetric traits (NMTs) are often used by osteoarchaeologists in the study of human variation. Some NMTs are affected by environmental factors whereas others are genetic in origin. Such genetic variants have long been used to support the hypotheses on the history and divergence of human populations suggesting that some population groups can be genetically distinguished. However, when genetic NMTs occur in higher than expected frequency these can be interpreted as possible indicators of relatedness. This method is applied to a sample of 977 individuals from the Medieval Poulton Chapel, St. Owen's Church and Norton Priory Collections, U.K. One hundred and twenty-six cranial and postcranial NMTs were examined to determine: 1) the prevalence, 2) whether there are significant differences between the sexes and/or by age category, 3) if there is variation in mechanical and genetic NMT frequency between the three samples and, 4) to explore possible familial relationships through hierarchal cluster analysis and burial spatial distribution. It is thought that family members are often buried near one another, suggesting that individuals sharing similar genetic NMTs would be buried within close proximity to each other. This thesis has revealed the frequency of 126 NMTs for each sample. No significant differences were reported between the sexes at Poulton Chapel whereas significant differences were noted at St. Owen's Church and Norton Priory, especially for NMTs considered genetic in origin. For all samples, significant differences were found among the age categories. Intra-populational differences were explored between the three samples. The results of these comparisons highlight that 60 NMTs are shared between the Poulton Chapel and Norton Priory Collection, while St. Owen's Church only shares few traits with both sites. This suggests a probable geographical north-south divide between the three sites. Finally, the hierarchal cluster analysis identified probable familial relationships for the Norton Priory sample. This is supported by the burial spatial distribution and historical documentary evidence. Unfortunately, this analysis was unsuccessful for St. Owen's Church with limited results for the Poulton Chapel sample. Future research is required to incorporate aDNA analysis to confirm the likelihood of familial links within these sites, supporting the use of certain NMTs is the use of establishing familial relationships.

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Acknowledgments

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Chapter 1 Introduction

Nonmetric Variants of the Human Skeleton

Skeletal variants are often used by biological anthropologists in the study of human variation, providing information about possible gene flow, drift, and population similarity (Lane and Sublett, 1972). Other variants can provide information on functional morphology to explore the nature of interactions between an individual and their environment. This form of expression suggests that some skeletal traits are heritable and can reflect in their evolutionary significance. These characteristic traits have become the centre of recognising the changes in formation patterns within evolutionary pathways (Lovejoy *et al.,* 1999; 2002).

The terms nonmetric, discontinuous (Ossenberg, 1970; Molto, 1979; Brasili-Gualandi and Gualdi-Russo, 1989), quasi-continuous (Grüneberg, 1950; and Self and Leamy, 1978), discrete (Rightmire, 1972; Corruccini, 1974; and Ossenberg, 1976) and epigenetic (Hauser and De Stefano, 1989; Berry, 1963; Berry and Searle, 1963; and Berry and Berry, 1967) traits have all been applied to any morphological feature of the skeleton that is not measurable and are simply recorded as binary (present or absent) or categorical (according to expression type). These skeletal variants are found within the normal anatomical range of the human skeleton and can include additional sutures, facets, bony processes, and variations in foramina and articular surface shapes. Other anomalies can include disturbances to the development of the axial skeleton (Barnes, 1994) which are often considered pathological in form (Saunders and Rainey, 2007). In current osteological research, no distinctions are made between different categories of skeletal variants (genetic and mechanical), and for most archaeological sites, these traits are recorded and interpreted collectively. Although useful for a site skeletal report, the use of skeletal variants is of no added value to the site and its skeletal collection when interpreted this way. However, specific research focused on a single skeletal variant, or grouped variants can provide valuable insights for osteological research.

Research surrounding the observation and assessment of skeletal variants does have some benefit. This method of analysis is simple and inexpensive. It can be applied to fragmentary and/or damaged skeletal material, contributing a new view of the daily life of past populations. For example, mechanical markers can be easily observed providing a review and developed an understanding of activity-related activities within and between population groups. Skeletal variants that are genetic in origin only occur in a minority of skeletons and, when occurring at higher than expected frequencies, can contribute to the establishment of possible genetic relatedness and family lineages within and between population groups, especially if the retrieval of aDNA is not possible due to poor skeletal preservation or curatorial restrictions.

In this thesis, macroscopic observations of 126 morphological features of the human skeleton, often referred to as nonmetric trait(s), will be examined to contribute to the debate of the value of nonmetric traits in archaeological research. For this thesis, nonmetric trait(s), *abbreviated to NMT(s*), will be assessed for all individuals from three Medieval British populations; the rural Poulton Chapel (n=602) and Norton Priory (n=130) Collections from Cheshire, and the urban collection from St Owen's Church in Gloucester (n=265) for the first time.

1.1 Background

Observations of NMTs have been described by several anatomists since the late 17th century (Cox and Mays, 2010) and have been a subject of discussion ever since. Supernumerary sutural bones (e.g. Wormian bones) were first presented by Dorsey (1897) and from here, various researchers have started to discuss and describe the variants of the human cranium (Dixon, 1900, Russell, 1900; Sullivan, 1922; and Stallworthy, 1932), including development defects such as bilateral nasal hypoplasia (Wood-Jones, 1936). A truer understanding of what lay behind these skeletal variants only began to appear in the 1950s when Grüneberg (1950; 1951; 1952) examined the genetics behind some skeletal variants seen in mice. These variants are demonstrated to be genetic by the range of variation in frequency among inbred strains of mice, as well as wild populations. These characteristics were validated particularly well with the absence of third molars. Grüneberg believed that the part of the genome responsible for NMTs was likely to be polymorphic (i.e. has multiple forms) and polygenic (i.e. multiple genes). He quickly quoted the term "quasi-continuous" after he noted that the third molars in mice did not necessarily erupt but there is a continuous genetic basis for this trait although the expression is discontinuous (the molar is neither absent or present). Through further cross-breeding of mice, Grüneberg suggested that there are developmental thresholds within the genes for the expression of a particular trait. This was reflected in mice caught in the wild that were also characterised by their traits, showing that relationships between populations can be assessed.

Grüneberg's research had hinted at developmental thresholds within a genome. This concept of the developmental threshold was later developed by Falconer (1965) who identified that the distribution of NMTs was the result of an individuals inherited tendency to develop a trait in combination with other factors that occur throughout an individual's ontogeny. This, in turn, makes them likely to develop an NMT (Falconer, 1965). Falconer assumed that these ontogenic factors were normally distributed over a population and, the point after which all individuals within a population would show a trait was named the "population threshold" (Falconer, 1965). Finding that the frequencies of NMTs can be used to characterise mice populations genetically combined with the developmental threshold model by Falconer (1965), provided the opportunity for researchers to study biological distance through NMTs (Berry, 1963). Numerous studies explored the potential value of NMTs in the ability to trace biological affinity and movement of extinct populations. Discrimination between major population groups was made. However, some gene frequency ratios could not be confirmed inferring that relationships depend on a relative degree of similarity or divergence between groups (Laughlin and Jørgensen, 1956). The most notable work reported in Berry and Berry's (1967) paper '*Epigenetic Variants of the Human Cranium*' examined minor morphological variations of the human cranium. Their paper brought together a definitive list of 30 cranial traits, with each trait described in some detail. These traits were analysed in 585 crania from various populations in Egypt, America, Nigeria, Burma (Myanmar) and Palestine. However, no juvenile specimens were included in this study. Berry and Berry (1967) stated that there were many differences in the prevalence of individual traits between populations, highlighting the significance of using cranial traits as a possible reflection of genetic differences. Berry and Berry (1967) described NMTs as being an expression of developmental genes and purposely used the term "epigenetic" to emphasise the likelihood of modification during development. They also stressed that they did not find a relationship between a specific gene and a specific NMT (Berry and Berry, 1967). Since this study produced good results distinguishing between the population groups and, as no significant differences between sex and age were found, Berry and Berry suggested that the use of such NMT data is superior to the use of metrical data in the reflection of genetic differences. This paper sparked the use of skeletal variants seen in the cranium as a proxy for assessing ancestral differences between archaeological populations, exploring the review of inter-relationship between cranial metric and nonmetric variation.

Since Berry and Berry's (1967) statement, this method was applied to other collections, focusing solely on the study of the geographic origin and evolutionary trends across and within various population groups (e.g. Pietrusewsky, 1978; Wijsman and Neves, 1986; Ishida, 1995; and Hefner, 2009). The assumption is that all traits will discriminate amongst populations making it easier to distinguish between different population groups. However, too much variability was apparent, and greater success was found when studying population structure and relationships (Kellock and Parsons, 1970; Ossenberg, 1976; 1977; Ishida and Dodo, 1993; Prowse and Lovell, 1995; 1996; and Hanihara *et al*., 2003). During this development, research by Corruccini (1974; 1976) tested the relationship between the cranial traits and craniometrical analysis and found significant correlations between them. However, he states that "it is impossible to infer causation from correlation statistics alone. Either variation may be the impetus for variation in the other, or they may be functionally independent but both dependent on another, unrecorded stimulus" (Corruccini. 1976). Corruccini also noted significant differences between age and sex in the traits studied, contradicting the results by Berry and Berry (1967). Additional research has since supported this notion (Carpenter, 1976; Rightmire, 1976; Cheverud *et al*., 1979; Derish and Sokal, 1988; Konigsberg *et al*., 1993 and O'Loughlin, 2004).

It must be noted that NMTs are not restricted to the cranium as numerous postcranial traits have been identified throughout the human skeleton. Unfortunately, these traits have received very little attention in comparison to their cranial counterparts (Anderson, 1963; 1968). In 1978, Finnegan presented 30 postcranial traits, each trait annotated and applied these to 196 individuals as an indicator of population distance between the Eskimo and Aleut populations. Finnegan suggested that these traits were "better suited" than the use of skeletal variants from the crania as these traits are bilateral in expression, these traits are more likely to survive through most archaeological contexts and, they are sexually dimorphic. In conjunction with this, Trinkaus (1981) supported the use of postcranial traits. However, it has been noted that some are produced by factors such as mechanical stress and/or by environmental factors (Kennedy, 1989). During the 1980's, research into NMTs started to decline, though a few articles were published.

Today, research on NMTs is increasing once more. In particular, dental NMTs, as standardised by the Arizona State University Dental Anthropology System (Turner *et al*., 1991; and Scott and Turner, 1997) are widely used to distinguish between major human populations (Irish, 1998; Irish and Guatelli-Steinberg, 2003; Hanihara and Ishida, 2005; and Hanihara, 2008). In archaeological collections, teeth are the most frequently well-preserved material of the human skeleton, and this is also true for a large proportion of human fossils. Research concerning dental NMTs is primarily focused on human variation within and among geographic regions in the aid to understanding patterns of modern human diversity, demographic history and familial affinities (Turner 1987; Haydenblit, 1996; Irish, 1998; and Irish, 2005). It is accepted that dental NMTs have a strong genetic component which is responsible for their occurrence and expression with little or no sexual dimorphism (Scott and Turner, 1988). Overall, dental NMTs will likely be the most dependable traits to consider for this area research. However, this study is currently being undertaken by another researcher at Liverpool John Moores University. Thus, only a few dental NMTs have been included in the overall 126 NMTs selected for this thesis. This thesis will now explore and clarify the complex nature and aetiology of NMTs with the potential to establish insight to possible familial lineages within archaeological skeletal assemblages.

1.2 Definition and Variation of Nonmetric Traits

Nonmetric traits are minor morphological variations of phenotypic expression that can be found in all body tissues. NMTs are often reported under other terminology such as discontinuous (Ossenberg, 1970; Molto, 1979; Brasili-Gualandi and Gualdi-Russo, 1989), quasi-continuous (Grüneberg, 1950; and Self and Leamy, 1978), discrete (Rightmire, 1972; Corruccini, 1974; and Ossenberg, 1976) epigenetic (Hauser and De Stefano, 1989; Berry, 1963; Berry and Searle, 1963; and Berry and Berry, 1967), or even all-or-none attributes (Cavalli-Sforza and Bodmer, 1971). For archaeological purposes, only skeletal and dental NMTs are relevant. These skeletal NMTs are expressions of the variations observed within bones and teeth and can include additional sutures, facets, bony processes, tubercles, crests variations in foramina and articular facets and, a range of other features. Other anomalies can include disturbances to the development of the axial skeleton (Barnes, 1994) which are often considered pathological in form (Saunders and Rainey, 2007). Over 400 NMTs have been recognised within the human skeleton. As these skeletal variants are highly heterogeneous, an underlying classification is required to illustrate and understand the wide range of variation a researcher may encounter while examining NMTs:

- *Variation in the number of bones.* A typical adult skeleton consists of 206 bones. However, some individuals may have more or fewer skeletal elements. For example, some individuals can exhibit an extra lumbar vertebra or in rarer cases, an extra thoracic vertebra and an accessory rib. This phenomenon usually occurs during foetal development where an abnormal number of somites are developed (McCollum *et al.,* 2010). However, the opposite can also occur where fewer somites are developed leading to missing vertebral elements.
- *Anomalies in bone fusion*. Certain skeletal elements may fail to fuse. For example, the metopic suture. Retention of the metopic suture, Metopism, is a frequently recorded trait found in most archaeological collections. This suture typically disappears during infancy and early childhood at approximately two to four years of age (Schaefer *et al.,* 2009). However, in some cases, this suture is retained into adulthood. On the other hand, some skeletal elements that should be separate entities can remain together. A typical example is block vertebrae which can occur anywhere along the vertebral column (Barnes, 1994).
- *Articular facet variation*. Articular facets usually occur at the site of a joint. Variation in form, size, or location of articular facets can occur. For example, the tibia squatting facet is a habitual movement at the joint that leads to an extension of the articular surface (Mays *et al.,* 2007). Another example is the variation observed of the talocalcaneal joint surfaces. The talus is a weight-bearing joint and numerous variations in the articular surface has been reported (Bilodi, 2006) revealing that gait and walking habits can lead to such variations.
- *Variation in foramina***.** A foramen is a perforation in the bone that usually occurs to convey nerves or blood vessels. There is variation in size, number and location. For example, the supraorbital foramen is located superior to the orbital cavity and is a passage for the supraorbital artery and nerve which provides sensation to the forehead (Chrcanovic *et al.,* 2011). Typically, a single foramen is present for both sides. However, these arteries and nerves can sometimes split creating two perforations in the same area. The entry/exit point location can also vary (Loukaus *et al*., 2008).
- *Hyperostosis and hypostosis variations*. This division of hyper- and hypostotic traits was developed by Ossenberg (1969) and has proven essential in the understanding of NMTs. Hyperostotic traits are characterised by an excess of

bone formation. However, this definition can incorporate numerous different reasons as to why the excess bone is formed. The ossification can include the ossification of soft-tissue structures such as cartilage or ligaments. An example of a hyperstotic trait would be a supracondylar process which is typically observed in the humerus and/or femur (Mays, 2008). On the other hand, hypostotic traits are characterised by incomplete or arrested development within or between bones. In this case, the humeral septal aperture and the sternal aperture are both typical examples of a hypostotic trait (Saunders, 1989).

It must be noted that NMTs do not usually cause medical symptoms and will largely go unnoticed. However, some NMTs are more noticeable (e.g. mandibular torus or maxillary torus) and can often be recorded on radiographs and other medical scans (e.g. sternal aperture). Occasionally, changes reported within the vertebral column can lead to discomfort. Barnes (1994) has published an extensive review of the developmental defects of the axial skeleton. Here, neural tube defects can vary from a minor disturbance to a severe abnormality. These are uncommon in modern populations, and little is known about them within the archaeological record (Barnes, 1994; Mays, 2006; Roberts and Manchester, 2010). The occurrence of neural defects is far more common in younger individuals and are often referred to as birth defects (Gregg *et al.,* 1981; and Bamshad *et al.,* 1999). However, this leaves a proportion of developmental defects that are not apparent until later childhood, adolescence and/or adulthood, depending on the defect and its location (Barnes, 1994). The most common vertebral defects recorded in archaeological populations include spina bifida occulta (e.g. Ortner and Putshar, 1985; Aufderheide and Rodríguez-Martín, 1998; Mays, 2006; and Kuma and Tubbs, 2011), deformations of the axial skeleton (e.g. Porter and Park, 1982; Henneberg and Henneberg, 1999; and Mays, 2007), abnormal cranial suture development (e.g. Barnes, 1994; and Roberts and Manchester, 2010), spondylolysis (e.g. Lovell, 1994; and Weiss, 2009), block vertebrae (e.g. Merbs, 2004; and Silva and Ferreira, 2008) and, lumbarisation and sacralisation (e.g. Carrott *et al.,* 2004; and Cottage and Wilton, 2011). Hauser and De Stefano (1989) emphasise that NMTs can have a medical relevance and state that the presence of many hypostotic traits is often noted in individuals with overall physical arrested development.

1.3 Studies of Specific Nonmetric Traits

As previously mentioned (see 1.1), the observation of skeletal NMTs have been described by numerous anatomists since the late 17th century. However, the vast number of these descriptions and, the later papers to follow, only focused and dealt with clear, recognisable NMTs of the human skeleton (e.g. metopism, wormian bones and the humeral septal aperture). As various NMTs have been previously explored on an individual basis, a small selection of the available literature will be reviewed to provide a summary of some of the NMTs included in this research.

Probably one of the most notable and frequently recorded NMT of the human cranium is the metopic suture. The frontal bone of a human fetus is usually in two halves, separated by the frontal suture. This suture typically disappears during infancy and early childhood at approximately 2 to 4 years of age (Schaefer *et al*., 2009). In some cases, this suture, identified from the nasion to the bregma, persists into adulthood, and this condition is called metopism. Metopism is a frequently recorded variant of the human cranium. However, the frequency, persistence and completeness of this trait vary within and between different population samples (Kumar and Rajshekar, 2015; Wadekar *et al*., 2014; and Bilodi *et al.,* 2003). Some studies suggest that the presence of metopism is highly correlated with supernumerary sutural bones and asymmetry of the cranium (Dorsey, 1897; and Hess, 1946). Supernumerary sutural bones are isolated bones of variable size and shape that can be observed along the sutures and fontanelles. Expressions of such NMTs can be collectively reported as wormian bones. However, definitions are often inclusive of the cranial location of the variant (e.g. lambdoid ossicle and bregmatic ossicle). Succeeding research has been unsuccessful in identifying whether the frequency of supernumerary sutural bones is due to cranial deformation or between population variations (Bennet, 1965; and Ossenberg, 1970). Further research on the effects of cultural practices of cranial deformation on supernumerary sutural bones presented no significant differences in the prevalence of these variants between deformed and un-deformed crania (El-Najjar and Dawson, 1977; and Konigsberg *et al.,* 1993). El-Najjar and Dawson (1977) noted that supernumerary sutural bones were observed in foetal crania for which they stated that artificial cranial deformation has little effect on the presence and absence of these variants, suggesting a likely genetic component in their formation.

Various postcranial traits have been identified (Finnegan, 1978; and Brothwell, 1981). However, little research has been devoted to their study. Some NMTs are routinely recorded during osteological analysis as they are easy to score and feature in standard laboratory manuals (Bass, 1971; Brothwell, 1981; Buikstra and Ubelaker, 1994; and White and Folkens, 2005). A frequently recorded NMT of the postcrania includes the humeral septal aperture which is a perforation of the bony lamina that separates the coronoid and olecranon fossa in the supratrochlear area of the distal portion of the humerus (Mays, 2008). This trait has been reported since the early 19th century, and some research has found a correlation between bone robusticity and the frequency of this variant (Benfer and McKern, 1966) although the opposite conclusions have been drawn by other authors (Cavicchi *et al.,* 1978). Mays (2008) provided a detailed study of the morphology of this NMT and identified further variation in the perforation as some individuals did not present full perforation of humeral septa. Mays suggested that the results indicate possible mechanical causation although further work is required to identify this relationship. Interestingly, these studies do highlight that the frequency of this NMT trait is often higher in females than males and this perforation often occurs more frequently on the left side than the right (Benfer and McKern, 1966; and Mays, 2008). Another frequently recorded trait of the postcrania is the third trochanter of the femur. The third trochanter is a rounded bony projecting that is located on the superior end of the gluteal tuberosity, localized underneath the greater trochanter of the femur. The third trochanter resembles the lesser trochanter, but it is an osseous prominence or tubercle (Bolanowski *et al.,* 2005) oblong in formation. This NMT is commonly used in quantitative studies of population affinities (Finnegan, 1978; Sciulli *et al.,* 1984). Research by Lozanoff *et al.,* (1985) explore the manifestation of the trait in relation to femoral morphology, essentially exploring whether the third trochanter is associated with a specific metric and/or shape pattern displayed by the human femur. They found that this NMT does possess "genotypic and phenotypic attributes" which prove useful in bio-distance studies amongst human populations. They also noted that the expression of the third trochanter is not affected by sex or by age, and this trait typically occurs bilaterally, like the findings reported by Finnegan (1978). They summarised that the third trochanter should prove useful in the discrimination of human populations. This review only covers a handful of the NMTs observed and reported for this thesis. This thesis does include full descriptions and illustrations for each NMT (see Appendix 1 and 2) developed by the author for ease of use. Details concerning the recording procedure for each NMT is clarified in Appendix 1.

1.4 Nonmetric Traits: Embryology and Genetics

The main areas of research surrounding NMTs have provided valuable information on the prevalence of individual traits within numerous population groups. However, the nature and causation of these NMTs have not been resolved. This undetermined level of understanding provides issues surrounding the use of NMTs in population analyses. As the biology of these skeletal variants can cover a wide range of topics, the embryology and genetics are briefly reviewed here.

- *Embryology and Development:* The development of NMTs can be considered as ontogenic in course and in combination with genetics, make up specific details of a trait. Unfortunately, the embryological development of NMTs remains poorly understood. The general progression of bone growth in the human foetus suggests that the fundamental factor of trait expression lies within the soft tissues that surround the osteogenic tissues (Richtsmeier *et al.,* 1984). However, the extent of the development of a single trait may be explained as the outcome of osseous growth and adaptive processes. This process can be illustrated by the example of branching nerves or vessels which may result in the formation of multiple canals or foramina. While the branching itself can be genetically explained, the formation of the canals or foramina depends mainly on interdependent growing processes (Hauser and DeStefano, 1989). Relatedly, the complex structure and development of an individual's cranium during early development follows a typical trend (Tyrell, 2000) and, for this reason, the NMTs of the cranium are considered preferable to post-cranial NMTs. However, functional changes, especially occlusion of the dentition after dental eruption can lead to functionally modified NMTs due to the stresses applied to the splanchnocranium. Nonmetric traits of the postcranial skeleton are more susceptible to functional remodelling and modification in comparison to the cranial counterparts. Such modifications can vary greatly during an individual's lifetime meaning that postcranial NMTs are less suitable for bio-distance studies.
- *Genetics and Heritability:* All NMTs can be regarded as threshold characters, a term developed by Falconer (1965). Falconers' (1965) model suggests there is a course that leads to developing a single trait. This course represents the individual inherited a tendency to develop a single trait and the whole combination of circumstances that make the individual more or less likely to do so. Whether the individual shows the trait or not, depends on their position

relative to the threshold. If the threshold is met, the trait will manifest. The individual's genes, together with the environmental effects will result in the different variations of trait expression (Falconer, 1965). However, the genetic basis of NMTs is fought with numerous difficulties. The hypothesis is that NMTs are inherited either due to a shared similar pattern of distribution to the known heritable material, or because they can be shown to have a probable genetic basis in humans (Tyrell, 2000). Referring to the research by Grüneberg (1963), his research identified that certain strains of lab mice consistently yielded individuals with missing third molars. These individuals also had smaller and more variable teeth than strains of mice with a third molar. Grüneberg concluded that tooth size was an inherited characteristic, rather than the absence of a certain tooth. If the tooth germ was too small, the tooth fails to develop, i.e. when its prospective size falls below the threshold level (Grüneberg, 1963). It must be noted that it is uncertain if these same characteristics are similar to the development of humans although it is deemed reasonable to suppose that the genetic basis is not completely different (Berry and Berry, 1965). Twin studies allow researchers to examine the overall role of genes in the development of an individual trait or a biological disorder. A variety of research has been undertaken to compare between monozygotic (identical) and dizygotic twins (non-identical) to evaluate the degree of genetic and environmental influences on a specific trait. Frequently, NMTs of the dentition are commonly investigated in twin studies probably due to the ease of accessibility in obtaining dental casts from living individuals (Wood and Green, 1969; Biggerstaff, 1970; 1973; Townsend and Martin, 1992). For all individuals, different genes can affect the dentition including a variation in the number, size and shape of various teeth. Numerous anomalies and variations of the third molar have been reported in humans, supporting the research presented by Grüneberg (1963) in mice. However, it has been reported that the type of variation can differ between twins, particularly for the third molar although other teeth can also present such variation (Townsend *et al.,* 2015).

1.5 Inter- and Intra-Population Studies

Nonmetric traits have frequently been used to estimate ancestry and bio-distance (similarity between skeletal populations) by quantifying the amount of NMTs as a measure of genetic relatedness. These studies are performed under the assumption the NMTs are genetically inherited. However, their polymorphic nature in combination with environmental factors has made researchers more cautious in their conclusions about bio-distance. Nonmetric traits have shown a wide range of variation within and between population groups. When studying NMTs, various internal and external factors must be considered for their influence:

- *Sexual dimorphism* can affect the prevalence and/or expression of a trait between males and females within populations at both an inter- and intra-population level. Numerous studies, both from anthropological and clinical research have explored sexual dimorphism of various NMTs with some literature recognising that there is little or no sexual dimorphism in NMTs (Corruccini, 1974; Dodo, 1974; and Mouri, 1976). However, significant sex differences have been noted since Corruccini's (1974) paper (see Buikstra, 1972; Berry, 1974; Perizonous, 1979; Korey, 1980; Hauser and De Stefano, 1989; and Kitagawa *et al*., 1995) identifying that there is a variability in the appearance and expression of some NMTs between the sexes. Hauser and De Stefano (1989) state that "if (the) frequency and variation in these traits is biologically meaningful, one would expect each to show parallel trends in the two sexes", this suggests that NMTs should occur at an equal rate in males and females, if this does not occur, the NMT may be sexually dimorphic. This relates to an earlier statement by Berry (1975) who highlights that this lack of consistency between the two sexes suggests that many of these NMTs are the "outward manifestation of the activity of genetic, epigenetic, and even environmental forces". However, care must be considered in the material sample size and the categorisation of NMTs within statistical analysis during interpretation.
- *Age-related changes* are differences between age groups in the prevalence and/or expression of an NMT. It has been suggested that age does affect the frequency of certain NMTs although no convincing results have been achieved (Dodo, 1974; Perizonous, 1979; and Hauser and De Stefano, 1989). Buikstra (1972) emphasised the importance of the age-progressive nature of many NMTs. Buikstra argued that the progressive ossification that is involved in hyperostotic traits may continue throughout ontogeny. This supports previous indications that hyperostotic traits are evident by early adolescence, even though the full expression may occur later in life (Buikstra, 1972). It may be concluded that age may be ignored when dealing with adult material but not with the pre-puberty material (Buikstra, 1972; Berry, 1975; and Perizonous, 1979).

- *Bilateral symmetry* is the tendency for a trait to occur on both sides of the body. It is assumed that a symmetrical biological organism would expect a tendency towards a bilateral occurrence of NMTs (Hauser and De Stefano, 1989). However, some studies have shown that NMTs do not always follow the expected path of symmetrical expression (Ossenberg, 1981) although Hauser and De Stefano (1989) suggest that the frequency of bilateral occurrences of a trait (++) is higher than the frequency of unilateral occurrence (+- and -+). Certain NMTs have a greater tendency towards bilateral expression (e.g. mastoid foramen), and numerous studies have identified a high side to side dependence for most NMTs (Perizonous, 1979; and Hauser and De Stefano, 1989). Alongside this, there are various discussions on how bilateral NMTs should be recorded. One method suggests counting a single side (either left or right) for all specimens (Haeussler *et al.,* 1988) while another method suggests scoring both sides and to account for asymmetry, count the side with the highest expression (Turner and Scott 1977). However, Ossenburg (1981) suggests that recording data for both sides have a stronger advantage of maximising the total information recorded for fragmentary remains. On a separate note, some NMTs are the result of possible mechanical factors. For example, NMTs related to activity-related changes such as the tibia squatting facet tend to be bilateral, as squatting is typically done with both ankles bent (Mays *et al.,* 2007) whereas NMTs such as the os acromiale are usually caused by unilateral activity. Several studies have provided support for the lack of laterality. For example, the dominant hand will have a different frequency of an NMT (Hauser and DeStefano, 1989).
- *Inter-trait association* is the tendency for the simultaneous occurrence of many different traits. Researchers often explore traits on an individual basis although this does not mean that they are necessarily independent. Association between certain traits is to be expected. For example, multiple sutural ossicles, or a double condylar facet and a double atlas facet. However, research into this area has produced inconclusive results (Hauser and De Stefano, 1989). On the other hand, Ossenberg (1969) observed a notable correlation between the number of hypo- and hyperostotic traits (e.g. metopism and one or more extra sutural bones) and other correlations have been found by other authors (Corruccini, 1974; Molto, 1985; Hauser and De Stefano, 1989; and Markowski, 1995). This highlights that some NMTs derive from a common fundamental process which

may be associated with their occurrence, whereas others are largely independent of one another.

Despite various complicating factors, NMTs traits have provided some support in the assessment of bio-distance in ancient populations (Tyrell, 2000). Archaeological kinship studies have been the interest of many anthropologists to aid the interpretation of social organisations within and between ancient societies (Pilloud and Larsen, 2011). This interest has led to the analysis of various population groups and social structures using dental morphological traits (Bondioli *et al*., 1986 and Adachi *et al.,* 2003), cranial (Strouhal and Jungwirth, 1979; Spence, 1996 and Velemínský and Dobisíková, 2005) and postcranial traits (Bondioli *et al*., 1986; Velemínský and Dobisíková, 2005). Some analyses apply metrical analysis (Bartel, 1979 and Bondioli *et al*., 1986), the frontal sinus (Hauser and De Stefano, 1989; and Cameriere *et al*., 2008) and with aDNA (Dudar *et al*., 2003; Bouwman *et al.,* 2008; and Haak *et al.,* 2008). These analyses consider various burial contexts (e.g. isolated double burials, small burial groups, large cemeteries with distinctly grouped areas) to determine plausible familial relationships. The use of NMTs for intra-population study evolves on the assumption that NMTs are heritable and that NMTs can, therefore, be used to suggest possible family relationships between burials. However, there are additional issues with this approach. Firstly, the preservation and completeness of individuals will essentially affect the number of NMTs recorded, and site plans will not report if the crania or other incomplete parts of the skeleton are missing. This is evident in highly used burial grounds where truncation of burials is a frequent and typical occurrence. Another consideration is the high number of burials of children, as children are still under a state of development so may not exhibit all NMTs until late adolescence (Buikstra, 1972). A final consideration surrounds the manner and burial practice of the Medieval period. Some issues occur where the children are buried separately, or a married woman will be buried with her husband and his family instead of being buried with her own family.

There are many variables that can complicate the interpretation of NMTs in osteological research. However, the use of NMTs in osteological research is common due to the simplicity and ease of recording in complete and fragmentary human skeletal remains. Nonmetric traits are simply recorded as binary (present or absent) or categorical (according to expression type). These skeletal variants can be unilateral, bilateral, paired or single, and can also be asymptomatic or pathological. A categorical recording system is potentially very useful as it provides and increased level of information. However, using a multiple level scoring system can be a complicating factor regarding statistical analyses (e.g. whether to decide to include a partial atlas bridge as present or absent) but also between inter- and intra-observer analyses. Relatedly, a common issue about NMTs is the lack of clear recording and scoring standards and definitions. It must be highlighted that many studies focus only on the 30 cranial traits from Berry and Berry's paper (1967) even though Ossenberg (1976) states there are ~200 cranial traits identified on the human skull. It is impossible to consider all these traits for a single population and shorter lists are often considered (Brothwell, 1981). Due to the wide range of variability between traits, a standardised recording or scoring system is yet to be established. This thesis aims to be clear about the NMTs included in this research. Here, the author has provided full descriptions and illustrations of the 126 NMTs (see Appendix 1 and 2) for ease of use in future analyses. The reasoning behind the selection of the 126 NMTs included here is explained in Chapter 3. Details concerning the recording procedure for each NMT will be clarified when appropriate (see Appendix 1) and finally, a random selection of NMTs have been subjected to inter- and intra-observer analysis to assess the repeatability of the data recording conducted for this research (Chapter 5).

1.6 Application of Research

One hundred and twenty-six NMTs from the Medieval Poulton Chapel, St. Owen's Church and Norton Priory Collections will be considered to distinguish plausible familial relationships within these collections. This research utilises 26 cranial traits from Berry and Berry (1967), 17 postcranial traits from Finnegan (1978) and a further 80 variants from across the skeleton which include some pathological variants (e.g. vertebral, axial and dental anomalies). Each variant will be recorded on a presence/absence basis, identified whether they are bi/unilateral and, when applicable if multiple traits have occurred. These skeletal variants will be recorded for all individuals from three Medieval populations; the rural Poulton Chapel (n=602) and the Norton Priory (n=130) Collections from Cheshire, and, the urban collection from St Owen's Church, Gloucester (n=265). Previous comparisons between rural and urban populations have shown differences in the prevalence of trauma patterns (Judd and Roberts, 1999), stature (Brothwell, 1994), and nonspecific infections (Lewis, 2002) but this has not been applied to NMTs. Trinkaus (1978) and Kennedy (1989) report that some postcranial skeletal variants are presentations of environmental and mechanical factors, most likely a response to biomechanical stress. Such activity-related traits will be explored to distinguish any rural/urban differences and, if possible, social segregations on the skeletal variants observed. Altogether, these skeletal variants can provide further information on population diversity, possible familial groups and activity-related differences between and within the Poulton Chapel, Norton Priory and St. Owen's Church Collections.

At the start of this research, very little material has been published about any of the sites. This provided the opportunity for thorough osteological analysis of the skeletal collections, with numerous research projects and subsequent publications. Norton Priory is in the forefront with a published monograph of all the archaeology (inclusive of human skeletal remains) excavated from 1970 to 1987 (Brown and Howard-Davis, 2008) and a paper focusing on the prevalence of Paget's Disease of Bone by Boylston and Ogden (2005). Several projects are underway on the Poulton Chapel and St. Owen's Church Collections by researchers at Liverpool John Moores University. These publications are inclusive of fracture and trauma analysis, age-at-death assessments, growth and development, dental NMTs analysis, multivariate approach to sex assessment and metric analysis of sexual dimorphism (Burrell *et al.,* 2017; 2016; 2015; Dove; 2017; Dove *et al.,* 2015; Rennie, 2017; Atterton *et al.,* 2016; Kuosa *et al.,* 2016; Martin *et al.,* 2016; Murton *et al.,* 2015; and Rennie *et al.,* 2015). Each publication is opening the possibilities of what these skeletal collections have to offer. The data presented here will be the first from which these variants have been recorded, and multiple publications can be considered (see Chapter 7).

1.7 Research Questions

Geographically, Poulton Chapel and Norton Priory are close to one another in comparison to St. Owen's Church (see Chapter 2). Interestingly, the city of Chester is located between Poulton Chapel and Norton Priory. Chester is the regional centre of internal and external commerce and has been since the Roman period with numerous industrial activities and bi-annual fairs (Bateson, 1903; Bu'Lock, 1972; and Whittock, 2009). This undoubtedly attracted local communities to visit and trade within this city, essentially leading to population intermixing, including those from Poulton Chapel and Norton Priory. On the other hand, St. Owen's Church lies outside the city walls of Gloucester. This population probably interacted directly with the city of Gloucester and essentially, local towns and villages. Due to the geographic location of these populations, it is possible that Poulton Chapel and Norton Priory could share similar skeletal variants and that St. Owen's Church presents a different selection of skeletal variants. Alternatively, the historical literature suggests that Poulton Chapel could be a self-sustained village (Morgan, 1978) proposing that interactions and population intermixing with Norton Priory could be more limited. Another consideration surrounds the social status of these two populations. The population of Poulton Chapel, based on the history of the local area are considered to be a rural farming community. While the community of Norton Priory is of a much higher social status and this is based on historical documents with distinctive burial practices. Essentially, this presents the possibility that each population may exhibit different skeletal variants to one another.

For this thesis, the following objectives have been identified;

- To establish and provide a detailed account of the demographics of the Poulton Chapel, St. Owen's Church and Norton Priory Collections.
- To document the presence of, and analyse the frequency of 126 NMTs within the Poulton Chapel, St. Owen's Church and Norton Priory Collections.
- To establish age relationships using skeletal variants (does age have an effect on the expression of skeletal variants?).
- To establish relationships between males and females through the analysis of skeletal variants (does sex effect the variants seen?).
- To establish spatial relationships of skeletal variants within the burial ground to explore possible familial relationships[1].
- To determine if skeletal variants associated with occupation differ in expression between rural and urban populations and, if possible, by social segregation.

This research hopes to provide an insight into possible familial relationships within the Medieval communities of Poulton Chapel, St. Owen's Church and Norton Priory. These analyses will permit comparisons to other collections from across the United Kingdom and hopefully, clarify how these populations fit within Medieval England.

1.8 Thesis Structure

Herein, this thesis contains seven Chapters. Chapter 2 and 3 cover the materials and methods applied in this research. Chapter 4 provides a detailed review of the demographics of each sample. Chapter 5 provides the results of the statistical analysis while Chapter 6 reviews burial spatial analysis as a possibility for distinguishing

[1] This will only occur for the Poulton Chapel and Norton Priory Collections as archival data for the St. Owen's Church Collection are incomplete.

plausible familial groups. These chapters are followed by a discussion of the results presented (Chapter 7) and the conclusions (Chapter 8) which summarise the study undertaken and the intended actions for future research. This thesis also provides an appendix which contains the illustrations and descriptions of the 126 NMTs included in this study.

Chapter 2 Materials

Sites Selected for Research

The Medieval period is defined by two significant events of English history, the first being the Norman Conquest in AD 1066 while ending with the battle of Bosworth in AD 1485 (Whittock, 2009). During this period, many political and noteworthy events unfolded including developments within the church, the language, industrial production and of course the social hierarchy. The social hierarchy was summarised by Mortimer (2008) into three tiers: those who fight, those who pray and those who work, each is further defined to distinguish between the Kings Men, Knights, Dukes, Lords, Merchants, Canons, Monks and Villagers. The daily routines of men and women are often depicted in manuscripts, sculptures, reliefs, drawings and paintings, each captivating the eyes into what Medieval life was like. These interpretations often portray men completing the heavier labour and work located away from the home (e.g. ploughing, tree felling, herding, hunting and war). Whereas women are often seen working close to the home, minding the children, milking cows and feeding the animals. Regardless, the treatment upon death followed a similar pattern for most populations. Individuals were typically buried in a Christian manner on an east-west alignment (Daniell, 1998) although social segregations sometimes persisted with burial. Here, the positioning of burials was affected by honour and by money, discriminating the burials of Lords, Clerics, Patrons to within the chancel and church walls, leaving the churchyard for the laypersons. It is interesting to note the high number of burial requests of men and women to be buried near or with their family members (Harding, 1992). There is also the possibility of further segregation within the church yard. The south side is often more favoured than that in the north as they wished to be buried nearer to the cross (Daniell, 1998). However, there is little evidence to support this theory.

The samples presented in the thesis are derived from the Medieval Poulton Chapel and Norton Priory in Cheshire, and St Owen's Church in Gloucester. These collections can be found along the western side of England within close proximity to the Welsh borders (see Figure 1). Each site follows similar burial practices, all are Christian burials with an east-west orientation but there are fundamental differences in the aspects of living and social status. Here, the histories, archaeological investigations and excavations of each site will be discussed.

Figure 1: Approximate site location of Poulton Chapel, Norton Priory and St. Owen's Church © C.L.Burrell

2.1 The Poulton Chapel Collection

The Poulton Chapel Collection is a continuously growing collection of human skeletal remains. They are subject of archaeological research as part of the Poulton Research Project, an active program since 1995. The Poulton Research Project is located in the rural village of Poulton, six miles south of Chester, in west Cheshire. This multi-period archaeological site overlooks the old Pulford Brook, a small stream that runs into the River Dee, now marking the border between England and Wales (Figure 2).

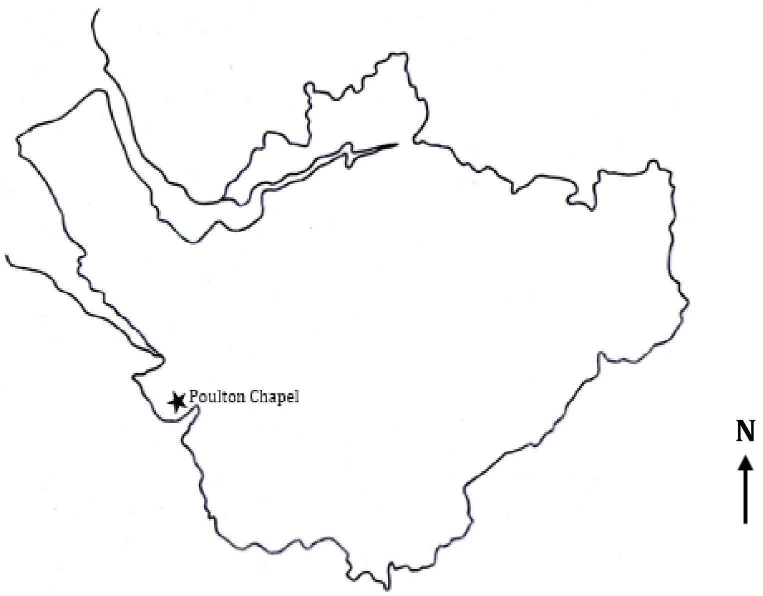

Figure 2: Map of the Cheshire County with approximate location of Poulton Chapel © C.L.Burrell

2.1.1 History of Poulton Chapel

The initial aim of the project was to establish the location and investigate the lost Cistercian Abbey of Poulton. The earliest documentary evidence of Poulton can be found in the Doomsday book of 1086 (Morgan, 1978) and the translated inscription reads as;

"*Richard Pincerna holds Poulton from the Earl Edwin. Edwin held it; he was a free man. One hide paying tax. Land for five ploughs. In lordship three ploughs, six ploughmen; a reeve and 3 smallholders with two ploughs. Eight acres of meadow. Value before 1066, 40s; later the same; now worth £4.*"

A charter of 1153 then confirms the foundation of the Cistercian Abbey of Poulton. Poulton Abbey was founded between 1153-8 by Robert Pincerna, Butler to the Earl of Chester. Numerous endowments of land were made to the Abbey making it the richest Cistercian estate in Cheshire (Wessex Archaeology, 2007). However, it was later transferred to Dieulacres in Staffordshire in 1214-20 (see Figure 3). Only the Grange and Chapel were maintained at Poulton by the monks. The Chapel remained in use until 1493 when the Abbot of Dieulacres leased the monastic land to a local family, the Manleys. The Manleys, in turn, developed the Chapel from a small single cell building into a fully developed Church adding a chancel and tower (Figure 4). Here, the chancel remained a private burial area for the Manleys (Emery *et al.,* 1995).

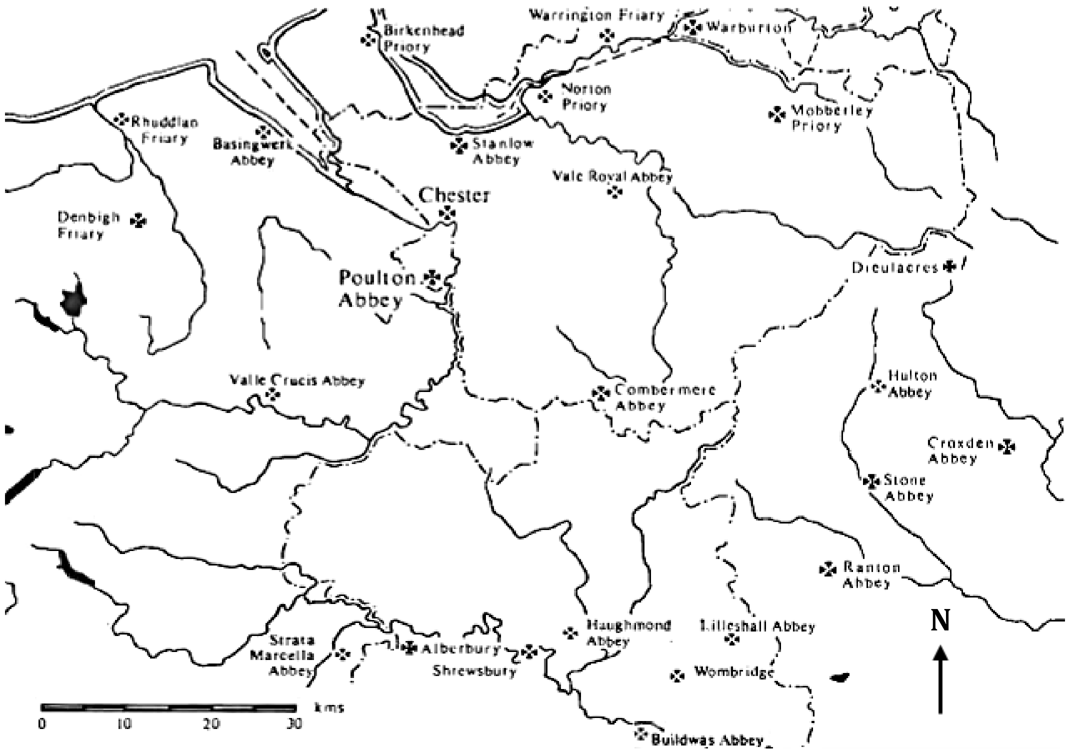

Figure 3: Map of the Medieval religious sites in the north-west of England (Emery, 2010)

Figure 4: Details of Poulton Chapel, taken from a 17th Century Estate map (Emery *et al.,* 1995)

Poulton Church was still in use in 1544 when parts of the estate where granted to Sir George Cotton but the Manley's remained as leaseholders. The last Manley at Poulton passed away childless in 1601 and the estate was handed over to the Grosvenor who still owns the estate today. In 1672, Poulton church was reported as ruinous and by 1718 it had been demolished with no visible remains above ground.

2.1.2 Previous Archaeological Investigations at Poulton Chapel

Mr R.G. Williams, a farmer who uncovered a large number of stones, produced the first string of archaeological evidence in 1892 and skeletal remains from the southern part of Chapel Field in Poulton (see Figure 5). During a later investigation in the 1960's, the same area of field was subjected to excavation by Mr G. Fair, the then landowner and farmer. Fair recovered some Medieval artefacts and fragmented human skeletal remains (Emery *et al.,* 1995). This promoted further investigations lead by head archaeologist Michael M. Emery in collaboration with the University of Liverpool and Chester City Council.

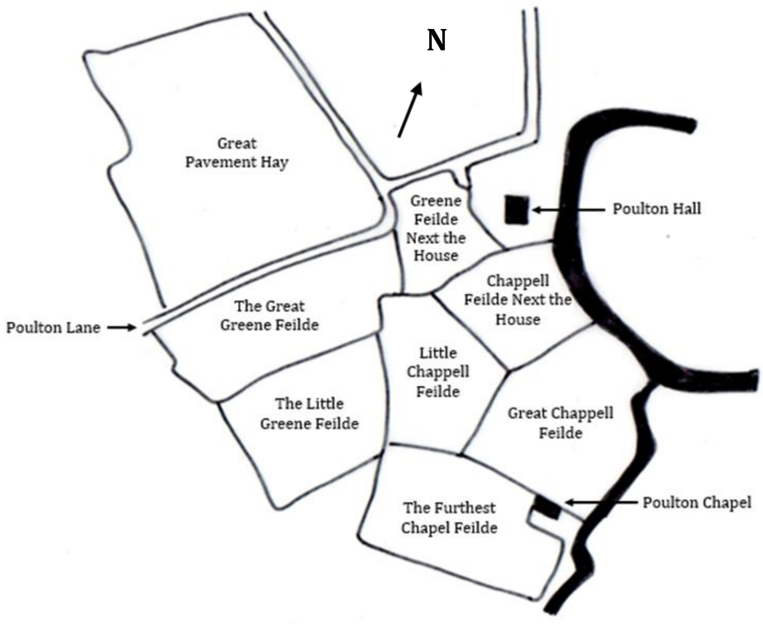

Figure 5: Adapted 17th Century Estate map of Poulton Fields
© C.L.Burrell

In 1995, geophysical surveys (resistivity) were taken, exposing the outline of what appeared to be a building (Emery *et al.,* 1995). During the period 1995-1996, the initial excavations uncovered the foundations of a small tripartite building. These were identified as a nave, chancel, and tower, all of which had evidently been expanded from a single cell building. This was recognised as Poulton Chapel. Interestingly, during the excavation of the Chapel, parts of a burial ground was also exposed.

Although the location of the Abbey is still under investigation, the current focus of the project is now the Medieval Chapel and its surrounding graveyard, which is thought to have been in use for about 400 years (Emery *et al.,* 1995; 2000) with the latest burial taking place in 1598 (Emery, 2000). To date, over 700 articulated skeletons and a considerable amount of disarticulated material have been recovered. Some individuals were subjected to radiocarbon analysis providing more accurate dates for the Chapel's usage. Unfortunately, little is known about the Chapel's early history although recent research of the ceramics from the earliest phase of the Chapel suggest that it was established sometime in the early 10th century, nearly 250 years prior to the construction of the Poulton Abbey. To this day, the site of Abbey remains elusive.

2.1.3 The Human Skeletal Remains at Poulton Chapel

The current focus of this site is the remains of the Medieval Chapel and surrounding burial ground. Since excavations began in 1995, over 700 human skeletons have been excavated along with large quantities of disarticulated bone. The skeletons recovered so far likely represent only a proportion of the total number of burials as excavations on the north and east sides of the Chapel have been minimal so far. It has been suggested that this graveyard may contain upwards of 1500 burials (Emery, 2013; pers. comms.).

Only initial reports are available for the earliest skeletal material recovered from the site (Quinney, 1996; Owens, 1998; Peers, 1999; and Roberts, 1998) as some of this early material has now been reburied. Up to the summer excavation of 2014, 791 burials have been identified from the Poulton Chapel. However, 71 of these skeletons have been recorded as either lost or reburied at Mount St. Bernard's Monastery, Staffordshire (Carpenter and Crane, 2003; 2010; and Burrell and Carpenter, 2012; 2013). Therefore, 720 skeletons have been utilised for this research. However, a further six individuals were identified during the osteological analysis presenting a final total of 726 individuals (see Chapter 3). Most of these individuals are housed at

Liverpool John Moores University (n=635) with a portion of the collection held at the University of Liverpool (n=91).

Fortunately, some individuals have been selected for radiocarbon dating. In 1998, one individual (SK53) was subjected to analysis. Unfortunately, the information obtained from this sample (OxA-8145) provided wide date ranges (Cal AD 1531 – 1804) and only the first date, Cal AD 1521-1591 seemed to be associated with the later phases of the Chapel (Burrell and Carpenter, 2013). In December 2012, an additional tooth root from SK53 (Beta-337188) and a tooth root from another individual, SK535 (Beta-337189), were subjected to radiocarbon analysis. This time results were more conclusive. The results reported state the results of the 2-sigma calibration as this gives a 95% probability compared to the 65% from 1 sigma results. The 2 sigma results for SK53 (Beta-337188) presented a single date of Cal AD 1450-1640 (cal BP 500-310) whereas SK535 presented two possible dates; Cal AD 1280-1320 (cal BP 670-360) and Cal AD 1350-1390 (cal BP 600-650). Interestingly, for SK535, this corresponded with the associated find of a M7 bodkin arrowhead found within the thorax cavity of this individual (Canavan, 2012). Recently, dates for two individuals with Paget's disease of bone were obtained (Burrell *et al.,* 2016) and both individuals presented two possible date ranges. Dates for SK463 were Cal AD 1275-1310 (cal BP 675-640) and Cal AD 1360-1385 (cal BP 590-565) and, the dates for SK750 were Cal AD 1285-1330 (cal BP 662-620) and Cal AD 1340-1395 (cal BP 610-555). These results are summarised in Table 1. Overall, these dates show that Poulton Chapel was in use from at least AD 1275 to 1640, corresponding with the historic information and chronology of Poulton Chapel.

Table 1: AMS Radiocarbon (^{14}C) Results for the Poulton Chapel Collection

Skeleton Number	Laboratory Number	Radiocarbon Age (BP)	2 Sigma Calibrated Date Range (95% Probability)
SK53	OxA-8145	-	AD 1521-1591 (14.8%), AD 1620-1683 (46.4%), AD 1736-1804 (27%)
SK53	Beta-337188	350±30	AD 1450-1640 (Cal BP 500-310)
SK463	Beta-425289	680±30	AD 1275-1310 (Cal BP 675-640) and AD 1360-1385 (Cal BP 590-565)
SK535	Beta-337189	670±30	AD 1280-1320 (Cal BP 670-360) and AD 1350-1390 (Cal BP 600-650)
SK750	Beta-425290	640±30	AD 1285-1330 (Cal BP 662-620) and AD 1340-1395 (Cal BP 610-555)

Nearly all the human remains were buried with an east-west orientation (head facing east), which is typical of Christian burials (Daniell, 1998). There are however, a few burials with the head facing west. Possible explanations include head to toe packing of multiple burials, limited space, carelessness, or deliberate ill treatment (Burrell and Carpenter, 2013). Even though this is unusual, it has been recorded at other Medieval sites (Daniell, 1998). Regarding the distribution of burials, there is a high number of non-adult burials located at the south west corner of the burial ground (see Figure 6) and no segregation between the males and females is apparent. Interestingly, there is a cluster of burials buried within the walls of the Chapel. This burial location suggests that these burials are of high status (Daniell, 1998). Unfortunately, this notion cannot be tested until the Harris Matrix of the surrounding archaeology has been verified. There appears to be no evidence of coffin burials at Poulton Chapel. From the tightly packed graves and the evidence of shroud pins suggests that shroud burials were quite prominent here (Burrell and Carpenter 2013). There has been little evidence of any associated finds with the burials at Poulton Chapel although there has been an arrowhead found within the thoracic cavity of two individuals (Canavan, 2012). On separate occasions, a belt buckle and a small knife blade has been recorded indicating that these individuals were probably buried clothed, suggesting a higher status burial (Burrell and Carpenter, 2013).

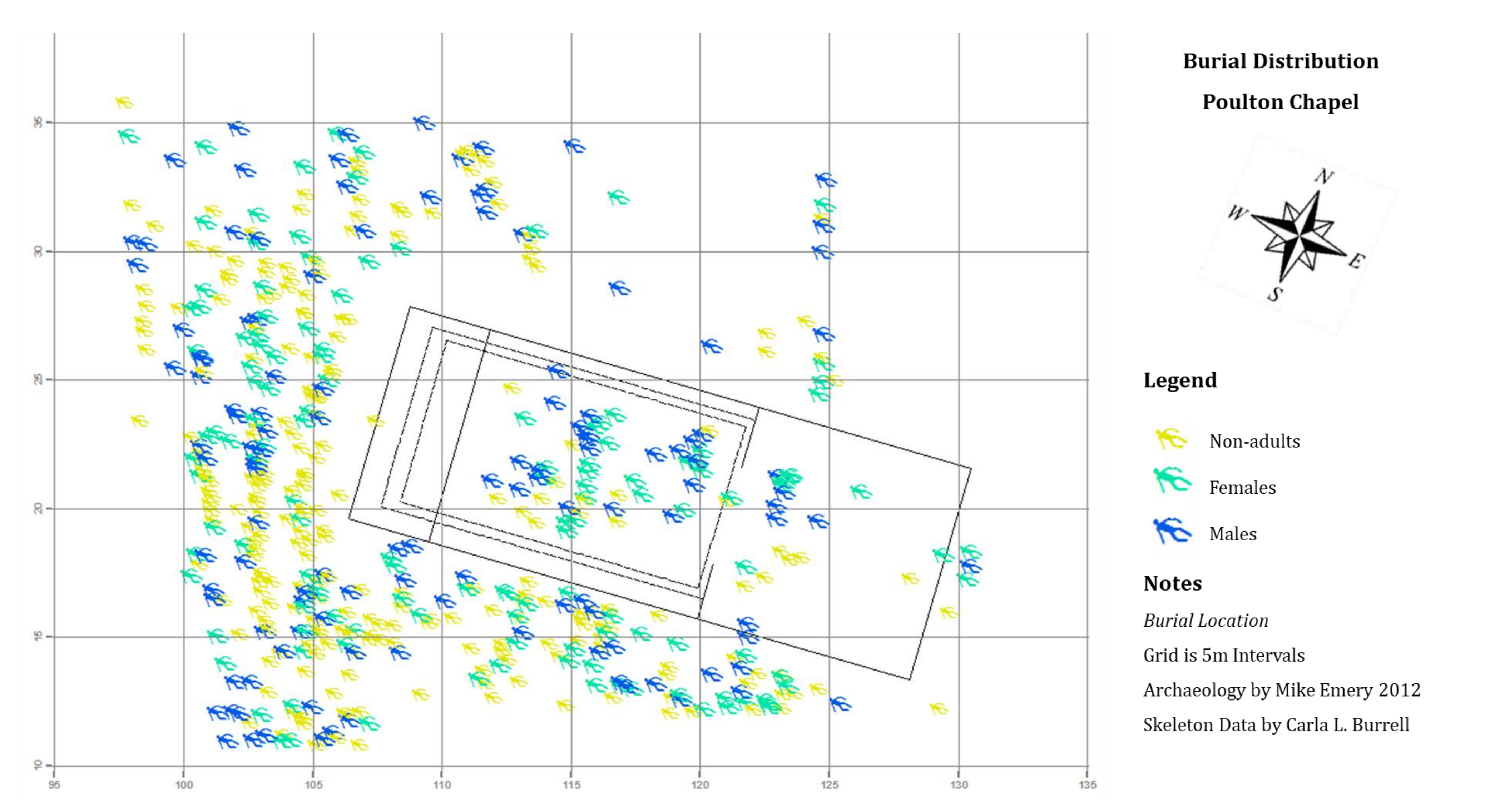

Figure 6: Burial distribution of the Poulton Chapel Collection

2.2 The St. Owen's Church Collection

The St. Owen's Church Collection is comprised of human skeletal remains from two series of excavations (1983 and 1989) by the Bristol and Gloucester Archaeological Society. The individuals were excavated from St. Owen's Church, Southgate Street, outside the urban settlement of Gloucester, Gloucestershire, located in the south west region of England. This multi-period archaeological site lies close to the Welsh border on the eastern bank of the River Severn (Figure 7).

Figure 7: Map of Gloucestershire County with approximate location of St. Owen's Church © C.L.Burrell

2.2.1 History of St. Owen's Church

St. Owen's Church, Southgate Street consists of two series of excavations in association with the Bristol and Gloucester Archaeological Society (Rawes *et al.,* 1990): 13/83 excavated in 1983 and, 3/89, excavated in 1989. However, many excavations have been undertaken in this area revealing fascinating information dating to the earliest phases of the Roman Conquest. The earliest record of Gloucestershire and Gloucester can be found in the surveys of the Doomsday Book 1086 (Morgan, 1978) and the translated inscription reads as;

"*In the time of King Edward the city of Gloucester rendered £36 by tale, and 12 sesters of honey according to the measure of the same borough, and 36 dickers of iron, and 100 rods of iron, drawn out, for nails for the King's ships, and certain other small customary dues in the hall and in the King's chamber*."

And;

"*Glouuescestre: King's land; Gloucester Abbey both before and after 1066. 5 fisheries, mill.*"

The history of Gloucester dates to the earliest phases of the Roman Conquest of Britain. This settlement flourished from the 2nd to 5th centuries and was maintained after the Romans withdrew from England at the end of the 6th century (Walker, 1976). It was during this time that the city of Gloucester suffered attacks from the Anglo-Saxons which lead to the city being abandoned but, occupations commenced during the 10th and 11th centuries (Atkin and Garrod, 1990) leading to the erection of new buildings across the city.

Fortification of the Roman city walls were completed, marking the borough of this urban community. As a result of the Norman Conquest, the foundations of St. Peters Abbey were established between 1058 in the north-west corner of the borough and a Priory (Llanthony Priory) was built southwest outside the city walls. Gloucester was favoured by English rulers in the 10th century and it may even have become capital of English Mercia (Walker, 1976). Another result of the Norman Conquest is the building of the Castle at Gloucester (see Figure 8). The Castle was built close to the River Severn where it dominated and controlled the quay on the Western border of the Roman walls (Walker, 1976). The Castle, likely built by Roger de Pitres the sheriff, was entrusted with the stronghold of Gloucester. This position was held as a hereditary possession and in turn his brother, Durand of Gloucester, took over until 1086. Durand's son, Walter of Gloucester then inherited the title and survived until 1100. Both men were loyal servants to Henry I and were given wider responsibilities and wealth. Miles, son of Walter soon succeeded his predecessor and became Earl of Hereford in 1141.

Over three generations, this family influenced Gloucester during the 11th and 12th centuries. With such wealth and responsibility, the link between this family, the Castle and St. Peter's Abbey was strong. Upon their deaths, both Roger and Walter were buried in the gardens of the Abbey. However, Miles was strongly interested in the Augustinian Order and the beautiful monastic sites that he built Llanthony Priory in 1108-10 (Brown and Howard-Davis, 2008) just outside of Gloucester, heading along the South road towards Bristol close to the River Severn (Atkin and Garrod, 1988). St. Owen's Church, founded in 1100, an ancient parish in the Diocese of Gloucester (Atkin and Garrod, 1990) is located just outside the walls of Gloucester, on the west side of the road leading from the southern gate (Figure 9). The Church lies slightly off the road, and is depicted with a chancel and small tower (see Figure 10). St. Owen's became a possession of Llanthony Priory in 1137 (Fullbrook-Leggatt, 1945) and remained in use until at least 1643 when it was later damaged during a time of siege. After this, it became a separate parish. From 1646 onwards, burials were interred at St Mary de Crypt, north of St Owen's Church within the walls of Gloucester. Unfortunately, St. Owen's Church was later demolished in 1847 during the extension of the docks and there are no visible remains above ground today (Atkin and Garrod, 1990).

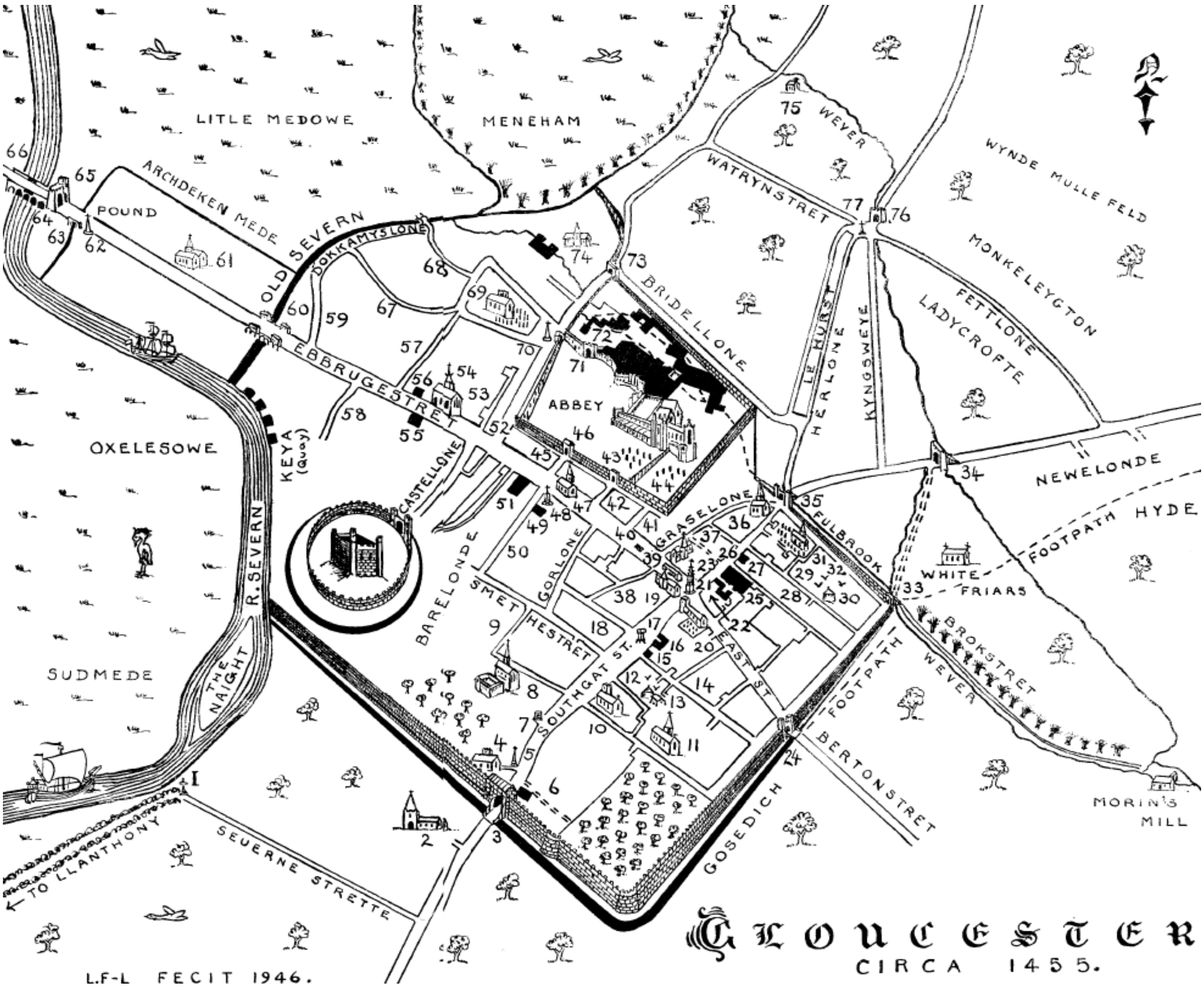

Figure 8: 15th Century map of Gloucester (Fullbrook-Leggatt, 1945)

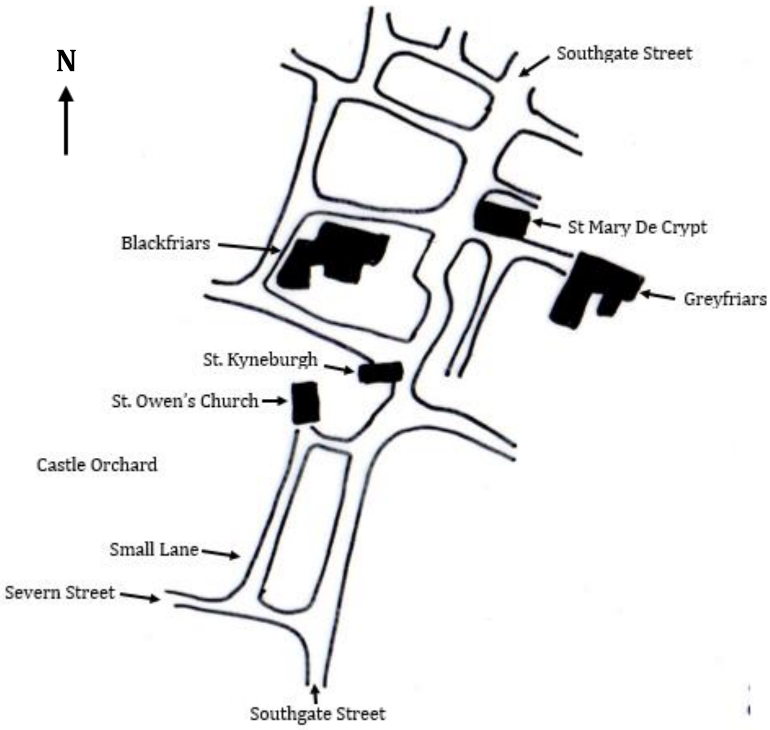

Figure 9: Adapted from a 15th Century map of Gloucester (Atkin, 1990)
© C.L.Burrell

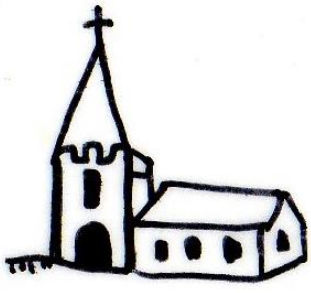

Figure 10: Details of St. Owen's Church (Fullbrook-Leggatt, 1945)
© C.L.Burrell

2.2.2 Previous Archaeological Investigations at St. Owen's Church

Archaeological excavations have been ongoing throughout Gloucester since the early 19th century, with the earliest recorded find found within the city walls, near the East Gate in 1806 (Fullbrook-Leggatt, 1968). Notably, a vast amount of work has been completed within and outside the city walls of Gloucester. There is a distinct increase in the total number of excavations following the late 1960s (e.g. Hunter, 1963; 1981; Abbot, 1967; Hurst, 1972; 1974; Hassall and Rhodes, 1974; Rawes, 1978; Atkin and Garrod, 1990; Hannan, 1997; and Holbrook and Bateman, 2008) with the last of excavations taking place in 1990 (Atkin, 1992).

St. Owen's Church lies outside of the walls of Gloucester and very little information has been recorded on the Church itself. Focus has remained on the suburbs of Southgate Street (Atkin and Garrod, 1989; Atkin, 1992; and Holbrook and Bateman, 2008) within the walls of Gloucester. The earliest mention of excavations at this Church was by Lysons (1860) who states that Roman Stone cists and burial urns were found and excavated during the expansion of the docks in 1847. It was not until the redevelopment of the docks, that further excavations took place at St. Owen's Church (Figure 11). The first excavation took place in 1983 (Rawes 1984) on behalf of the Western Archaeological Trust and the second in 1989 (Atkin and Garrod, 1990) by the Bristol and Gloucester Archaeological Society. Unfortunately, little is known and reported about the early history of St. Owen's Church.

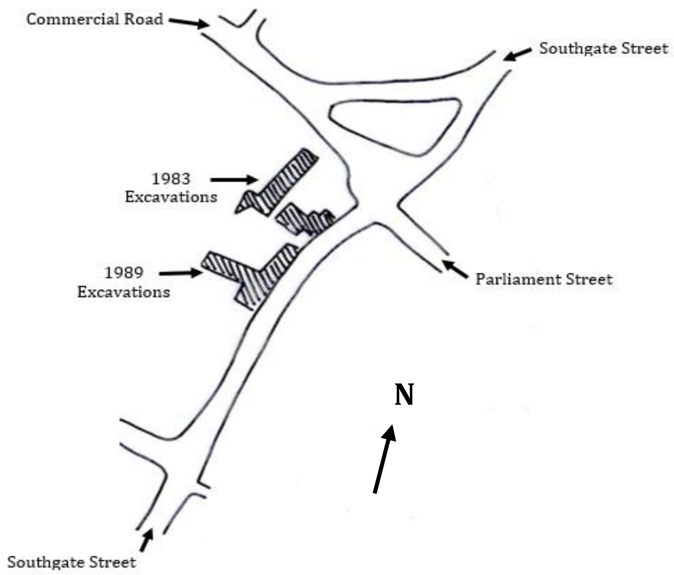

Figure 11: Location of excavation sites, adapted from Glevensis 24 (Atkin, 1990)
© C.L.Burrell

2.2.3 The Human Skeletal Remains at St. Owen's Church

The St. Owen's Church Collection is comprised from two series of excavations from St. Owen's Church. The first excavation took place in 1983 (n=71) and the second in 1989 (n=225) with a total of 296 Medieval burials identified and exhumed. The skeletons recovered only represent a portion of the total sample of individuals buried here. No osteological reports have been completed on these remains. However, as these remains are housed at Liverpool John Moores University, they are now the subject of various research projects.

As very little material has been published on this site, the research surrounding this skeletal collection is minimal. Currently, no radiocarbon dates have been obtained and very little is known about the burial distribution at St. Owen's Church. The archival records suggest that all the human remains were buried with an east-west orientation (head facing east), which is typical of Christian Burials (Daniell, 1998) with only one reversed burial (see Figure 12). The burial positioning seen within this grave plan suggests these burials are likely to be shroud burials. However, other archival plans suggest some coffin plate burials are evident at this site[2]. Individuals believed to be obtained from Coffin Plate burials have been reviewed for research purposes but these burials will not be included in this thesis. This thesis is focused on individuals from the Medieval period. As archival records are collated, exploration of the presence of NMTs through time (Roman through to the Georgian/Victorian period) can be considered for this collection.

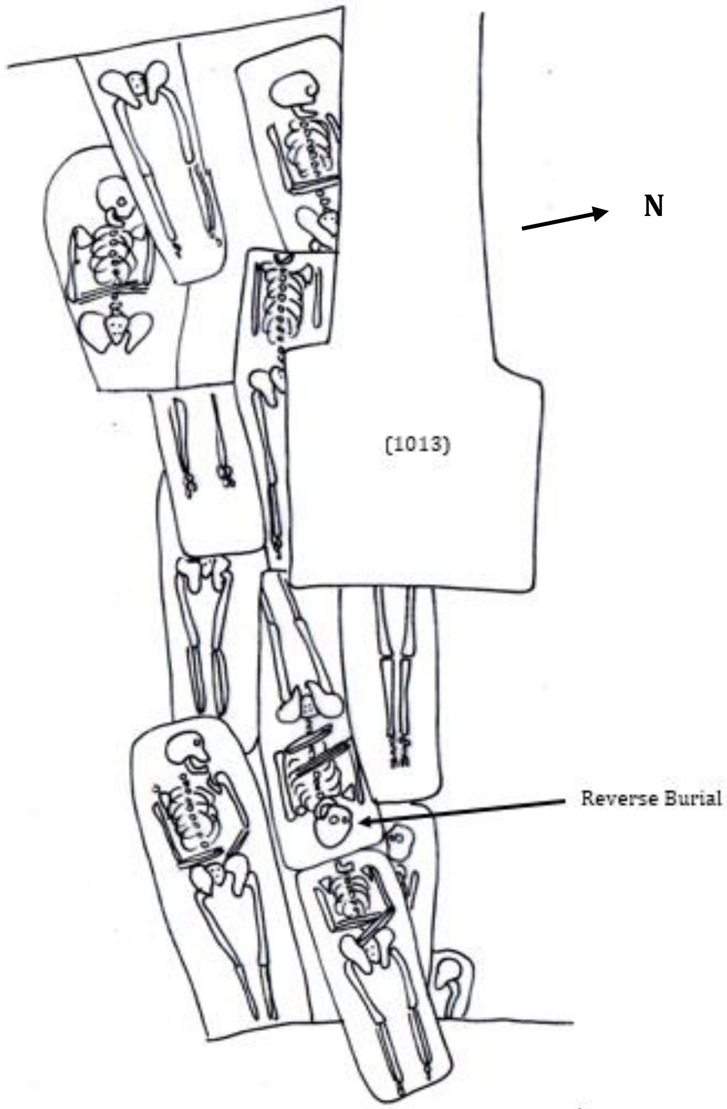

Figure 12: Graveyard plan of St. Owen's Church
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[2] As archival evidence is minimal, further research is required to understand the coffin plate burials and their location relative to the other burials and surrounding archaeology.

2.3 The Norton Priory Collection

The Norton Priory Collection has been defined by the human skeletal remains disinterred from the excavations of 1971-1978. They are subject to the archaeological research framework encouraged by the Trust of the Norton Priory Museum and Gardens. Norton Priory lies 2.5 miles east of Runcorn, less than a mile from the rural village of Norton, in northern Cheshire (Figure 13).

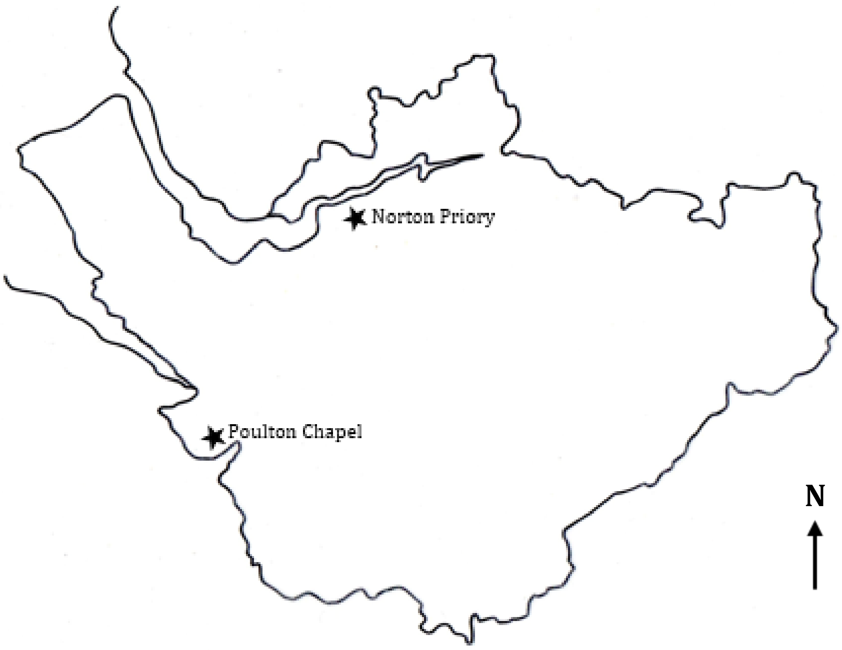

Figure 13: Map of the Cheshire County with approximate location of Norton Priory © C.L.Burrell

2.3.1 The History of Norton Priory

The Augustinian Priory, later the Abbey of Norton was originally founded in Runcorn, Cheshire, in 1115 during the reign of Henry I. Less than 20 years later in 1134, the priory was relocated to a more suitable site at Norton by William Fitz Nigel, the second Baron of Halton. The earliest documented evidence of Norton and Halton can be found in the Doomsday book of 1086 (Morgan, 1978). The translated inscription for Norton reads as;

"Ansfrid holds from him. Uhtred and Toki held it as 2 manors: they were free men. 2 hides paying tax. Land for 6 ploughs. In Lordship 1; 2 slaves, 3 villages with 1 plough, 1 fisherman. Meadow, 3 acres, woodland, 4 acres, 2 enclosures. Value before 1066, 16s; now 9s 4d."

And for Halton;

"Orm held it; he was a free man. 10 hides, of which 5 pay tax and the others do not. Land for 20 ploughs. In lordship 2 ploughs, 4 ploughmen, 4 villagers, 2 smallholders and 2 priests with 5 ploughs between them. 2 fisherman pay 5s. Meadow, 1 acre, woodland 1 league long and ½ wide, 2 enclosures, I unoccupied house in wich. Of the land of this manor Ordard holds ½ hide; Geoffrey 2 hides; Aethelhard 1 ½ hides; Humphrey1 ½ hides; Odard ½ hide; Hardwin ½ hide. In Lordship 3 ploughs. 12 villages, 1 rider and 5 smallholders with 5 ploughs between them; 6 ploughmen. Meadow, ½ acre, woodland 18 acres. Total Value of the Manor before 1066 40s; now, what William holds 50s, what the men at arms hold 54s."

Endowments expanded during the 12th Century by the main benefactors of the Priory, the Dutton family. In 1236, a great fire was reported to have taken place at the Priory and the extent of the damage remains unknown. However, the strong association of the Dutton family with Norton Priory lead to the refurbishment and extension of the Chapel's to the north and southern transepts (Brown and Howard-Davis, 2008). With the many endowments made by the Dutton family, the north-east chapel extension is believed to be closely associated with the Dutton family with many of the family members buried here (Greene, 2004). Unfortunately, during the mid-15th century the Priory started to fall into disrepair under a new Abbot and, with frequent flooding and then reduced funding, the conventional buildings were soon recorded as ruinous (Brown and Howard-Davis, 2008). By 1496, the total number of canons had been greatly reduced, but the Priory remained active until the dissolution in 1536. During this time, the Priory was stripped of its valuables (e.g. roofing lead, bells and stone) and then abandoned. The Abbey estate was later purchased by Sir Richard Brooke in 1545 and kept within the family for 200 years (Brown and Howard-Davis, 2008). Little change was made to the estate during this time until the house was later demolished and a new classical house was built during 1737-57, incorporating part of the original structure of the undercroft within the classical house. Unfortunately, due to local redevelopments, this building was later demolished in 1928 yet, astonishingly, the undercroft still remains today.

2.3.2 Previous Archaeological Investigations at Norton Priory

The foundations of the Priory were excavated during the 1970's through to the 1987 and at a total of 122 trenches of overlapping excavations. Till this day, this site remains as one of the most extensively investigated religious foundations in Europe (Greene, 2004). Excavations have revealed the advancement and changes of the Priory though the time periods, providing an insight into the sequence of development and growth of the Priory. From historical evidence, it had been documented that burials began in the late 12th Century and continued until the dissolution of 1536. The excavations resulted in the disinterment of numerous burials (see Figure 14). Here, the deceased are believed to be Augustinian Canons or important benefactors to the Priory. The Dutton family made numerous endowments to the Priory and are documented to have been buried in the north-east Chapel (Brown and Howard-Davis, 2008). Recently, three individuals were subjected to radiocarbon analysis, supporting the early usage of the Priory.

2.3.3 The Human Skeletal Remains at Norton Priory

A total of 128 Medieval burials have been exhumed across the Priory during the 1970's excavations. However, in some instances, graves contained skeletal material of one or more individuals, and with two charnel deposits, the total number of individuals is 165 (see Chapter 3). These individuals are housed on site by the Norton Priory Trust. The skeletons recovered only represent a portion of the total sample of individuals buried at Norton Priory. Figure 14 highlights two other possible areas where burials are located however, as excavations ceased in 1987, this idea remains unproven. Various osteological research has been completed on this skeletal collection; mostly masters and undergraduate research projects at the University of Liverpool. Unfortunately, these projects were never published. However, in 2005, Boylston and Ogden (Brown and Howard-Davis, 2005) published a review of all the remains, providing valuable information surrounding the demographics of this collection for the first time. More recent research on this collection has led to advancement into the understanding of the individuals buried here including radiocarbon dates on the tooth root of three individuals (Burrell *et al.,* 2016).

The results reported state the 2-sigma calibration results, as this gives a 95% probability compared to the 65% from 1 sigma results. The 2-sigma results for SK35 presented a single date of Cal AD 1155-1260 (cal BP 795-690). Whereas the two remaining individuals presented two possible dates; dates for SK22 were Cal AD 1050-1080 (cal BP 900-870) and Cal AD 1150-1250 (cal BP 800-700) and, SK101 were Cal AD 1280-1320 (cal BP 670-630) and Cal AD 1350-1390 (cal BP 600-560). These results are summarised in Table 2.

Figure 14: Burial distribution of the Norton Priory Collection

These dates provide a period for which burials at Norton Priory were taking place however, the earlier date for SK22 (AD 1050-1080) are likely erroneous as they pre-date the Priory which moved to Norton in AD 1134 (Brown and Howard-Davis, 2005). Excluding this date, the results support and correspond with the historic information and chronology of Norton Priory (AD 1150-1390).

Table 2: AMS Radiocarbon (^{14}C) Results for the Norton Priory Collection

Skeleton Number	Laboratory Number	Radiocarbon Age (BP)	2 Sigma Calibrated Date Range (95% Probability)
SK22	Beta-425284	860±30	AD 1050-1080 (Cal BP 900-870) and AD 1150-1250 (Cal BP 800-700)
SK35	Beta-425286	840±30	AD 1155-1260 (Cal BP 795-690)
SK101	Beta-425288	660±30	AD 1280-1320 (Cal BP 670-630) and AD 1350-1390 (Cal BP 600-560)

All the human remains were buried with an east-west orientation (head facing east), which is typical of Christian burials (Daniell, 1998). Many of the burials were buried in stone or wooden coffins with carved stone lids. This corresponds to the date range of the site stratigraphy and documentary information (Brown and Howard-Davis, 2008). There has been little evidence of any associated finds with the burials at Norton Priory. However, one burial was recorded with a simple belt buckle indicating that this individual was fully clothed when buried, suggesting a high-status burial.

2.4 Reflection of Selected Sites

Poulton Chapel, St. Owen's Church and Norton Priory are unique sites with populations worthy of further exploration. The population of Poulton Chapel is that of a rural sample, with numerous burials taking place over 400 years comprising of families from several generations who worked on the local farmlands. Similarly, the population of St. Owen's Church is considered an urban sample with burials taking place over a similar period. However, Norton Priory is a little different. Although burials have been taking place at Norton during the same period, significant recorded events (e.g. the 'Great Fire' of 1236 (see Brown and Howard-Davis, 2008)) have led to the refurbishment and extension of various sections of the Priory. These endowments were made by a local family, the Dutton family, who had these new areas of the priory dedicated to their family for burial. These families are considered of high status, in turn, their manner of burial differ to those seen at Poulton Chapel and St. Owen's Church. Many of the burials seen at Norton Priory are stone coffins with beautifully decorated stone coffin lids and, when compared to the simple shroud burials of Poulton Chapel and St. Owen's Church, the distinction between social statuses is noticeable between these sites. With this, each sample permits the exploration of different lifestyles, rural and urban divides and in some respects, social segregation which, in turn, provides a glimpse into the Medieval life of these individuals. Interestingly for Norton Priory, these dedicated areas of family burial provide an optimum chance to review NMTs of a particular family group. Very little information and research has been published on the human skeletal remains from these sites, especially for the Poulton Chapel and St. Owen's Church Collections. Several projects are now underway at Liverpool John Moores University and each publication is opening the possibilities of what these skeletal collections have to offer. The data presented in this thesis will be the first from which these variants have been recorded[3]. Equally, further research and publications can be explored for these skeletal collections (see Chapter 7).

The following chapter identifies the methods used to complete the osteological and statistical analysis to meet the research aims of this thesis (see 1.7). Osteological analysis is concerned with the determinations of the identity of a skeleton by assessing age-at-death, sex and stature. It is crucial in identifying sexual dimorphism with respect to occupation, life style and diet, as well as the role of different age groups within Medieval societies. The preservation and completeness of each individual is also a fundamental factor affecting both the methods used and the accuracy of the results. Here, the completeness of an individual will be evaluated. The preservation of these remains is currently being explored in connection with their surrounding burial environments as part of an on-going PhD project (Davenport, 2017). Additional analyses such as the recording of NMTs can provide further information on occupation and possible familial affinities. The analyses discussed in Chapter 3 will be completed on each individual from the Poulton Chapel (n=726), St. Owen's Church (n=296) and Norton Priory Collections (n=165). It must be noted that the final total of individuals is reduced for each sample due to factors leading to the exclusion of some individuals from the final analysis. However, the documentation produced during this research should give a representative analysis of each individual which can be used for future research and study of the population groups as a whole.

[3] Some nonmetric traits have been previously recorded for the Norton Priory Collection (Brown and Howard-Davis, 2005). However, as more traits have been selected for review in this thesis, the collection was reviewed for a second time.

Chapter 3 Methods

Osteological and Statistical Analysis

For this research, the analyses discussed in this chapter will be completed on each human skeleton from the Medieval Poulton Chapel, St. Owen's Church and Norton Priory Collections. Each skeleton will be reviewed on an individual basis and examined thoroughly. Collectively, these analyses will build a demographic profile of the population for each collection (Chapter 4). Unfortunately, there is no documentation available to confirm the identity of the individuals from these collections. Most individuals were shroud burials, buried in unmarked graves (at least, no markers now remain), leaving no hint as to who these people were in life. There are, however, a few instances of stone and lead coffins which can provide some clues about the wealth and status of the individual contained, but not who they were in life or who their family were. In some instances, burial position, location and associated grave goods can provide insight into the importance of the individual as a part of a given society (Pearson, 1993; Emery, 1996; Joyce, 2001; Mytum, 2006; Buckberry, 2007; and Brown and Howard-Davis, 2008). Occasionally, these individuals are noted in historical literature, so connections can be made. However, without confirmation of aDNA hesitation remains[4]. Nevertheless, skeletons do remain for most contexts and through the use of various osteological methods, the biological attributes and skeletal characteristics of each individual can be brought to the surface, providing valuable information about the people that once lived in these communities.

The methods discussed in this chapter have been accumulated from the vast array of research and literature available, each of which aids the assessment of an individual's age-at-death, sex and stature. Gathering this amount of information both on an individual basis and collectively for each population group allow for comparisons between the demographics of these selected sites (see Chapter 4). These analyses will permit comparison to other collections from across the United Kingdom and hopefully, clarify how these populations fit within Medieval England.

[4] This aspect of research is currently underway and forms part of the Wellcome Trust Fund for the Norton Priory Museum and Gardens Collection. Currently, only a few samples have been selected, if successful, further funding will be sought to review the rest of the collection.

3.1 Inventory

For the analysis of each skeleton, each element is inventoried as either complete or fragmented and recorded in sequence from the cranium to the feet on a presence/absence basis. Many methods have been developed to provide complete documentation of individual human skeletal remains (Buikstra and Ubelaker, 1994; Brickley and Mckinley, 2004; and Burns, 2007). These forms typically distinguish the skeleton into separate sections for efficient and thorough analysis. Examination of skeletal remains is completed most efficiently by laying the skeleton out in anatomical position (Figure 15). The form used during this research (Appendix 3) contains a series of tables sectioning the skeleton into specific areas, permitting an efficient recording method of the individual skeletal elements. Interesting pathologies or anomalies can also be described here.

Obtaining an inventory for each individual provides a clear interpretation of the completeness of the skeleton as some individuals have been truncated by other burials and archaeology. For easy interpretation, individuals are identified as more than 75%, almost complete as 50-75%, if less material is available then 25-50% or under 25% when there is very little material remaining. Photographs are also taken of each individual. Figure 15 shows a skeleton over 75% complete. Here, the individual is almost complete only a few fragments of crania, scapula, sacrum and a few foot and hand phalanges are missing. On the other hand, an individual considered to be less than 25% usually represents an individual as a skull only, or a partial section of an articulated skeleton (e.g. a set of lower legs with feet). This method of recording is based on the percentage of the bones present for each individual. A completed inventory form clarifies exactly which skeletal elements are present for each individual (Appendix 3).

Figure 15: An example skeleton laid out in anatomical position (Burrell and Dove, 2015)

Following the inventory, a post-excavation analysis form is completed (Appendix 4). This form records the standards for age-at-death, sex and stature for each skeleton. During this process, a differentiation of whether the skeleton is an adult or non-adult must be made. For the purpose of this research, an individual is classed as an adult when 18 years or older.

3.2 Minimum Number of Individuals

To determine the minimum numbers of individuals (MNI) present in each assemblage of skeletal remains, it is necessary to account for each bone, separating them according to type and side. The remains can then be counted and corresponded with the opposite side to determine the number of individuals present. Any duplicates, or bones of different age or sex suggest that more than one individual is present amongst the assemblage of remains (Adams and Konigsberg, 2004; White and Folkens, 2005; Nikita and Lahr, 2011 and Nikita, 2014). When MNI is greater than one and there is sufficient material accounting to a second individual, these are then recorded and treated as a new single individual. Unfortunately, this frequently occurs for infant burials that have simply been misidentified during excavation. In some circumstances, multiple crania can be found in the same context. Here, each cranium will be treated as a separate individual and in turn, reviewed and recorded accordingly.

3.3 Age-at-death Assessment

Age related changes in the skeleton may reflect three different phases of lifespan; growth and development, equilibrium and senescence. The first phase is represented by children and young adults who undergo changes that proceed at an orderly and well-documented pattern. Once growth has ceased, the changes in the adult skeleton vary greatly and are very individual and population specific (Marrille *et al.,* 2007; and Rissech *et al.,* 2011).

3.3.1 Non-adults

Assessment of age-at-death for non-adult skeletal remains (under 18 years of age) are more accurate than for adults because the former is derived from ontological changes. Assessments for age-at-death in non-adults are physiological ages that can be transformed into chronological ages (Ubelaker, 1987) by analysis of reference populations with known age-at-death. Physiological age is estimated by the maturation of multiple tissue systems including the appearance and union of epiphyses, the formation, loss and emergence of teeth, bone growth and stature, and, finally, sexual dimorphism of the bones.

Dental development is the best indicator of skeletal maturity and is well documented (e.g. AlQahtani *et al.,* 2010; Demirjian *et al.,* 1973; Moores *et al.,* 1963a; 1963b; and Ubelaker, 1987; 1989). For any individual, development of the dentition is a continuous process that begins during foetal life and continues until late adolescence. This process usually progresses through two overlapping stages of development; the deciduous dentition followed by the permanent dentition. For the purpose of this research, dental development was compared to the chart documented by AlQahtani *et al.,* (2010). When available, radiographs of the dentition were attained using a Hewlett-Packard Faxitron model 43855A (Faxitron Bioptics) with the Digital Linear X-Ray Scanner EZ240 and iX-Pect for EZ240 Software. The radiographs were calibrated at 60kv, 100ms to 110kv, 100ms, dependent on the development of the individual, the image was then processed using the MicroDicom 0.8.6 analysis software. This permits a more accurate interpretation of dental maturity and development for an accurate age-at death assessment up to 23 years of age (AlQahtani *et al.,* 2010).

There is a relationship between age and height in non-adults allowing diaphyseal long bone lengths to be a suitable method of age-at-death assessment (Ubelaker, 1987). Long bones form by endochondral ossification, with the diaphysis developing from the primary centre of ossification. This is primarily responsible for the increase in length of the diaphysis. The maximum lengths of the diaphysis can be measured to the nearest millimetre and assigned an estimated age-at-death from various recorded metric tables. During this research, the data recorded by Maresh (1970) which extensively documents the maximum diaphyseal lengths from a known age sample (n=255) will be used. The individuals included in her study were considered to be of northwest European decent and this study was recognised as a worthy longitudinal study by the World Health Organisation (McCammon, 1970). These data havs been extensively reviewed against the Poulton Chapel, St. Owen's Church and Norton Priory Collections; but also, the Abingdon and Spitalfields Coffin Plate Collections, housed at the National History Museum, London (Burrell *et al.,* 2015). Results support the use of Maresh's (1970) data as a proxy for age-at-death assessments for these collections and with no sex differences apparent between or within the age categories (up to twelve years of age) permits a suitable use for unknown collections. It must be noted that Maresh's (1970) data does include the long bone length measured with the epiphyses for older non-adults (ten to eighteen years of age). However, this portion of data were not applied against the material used in this thesis.

Epiphyseal union and fusion proceeds in an orderly manner during adolescence through to adulthood. It may be used to determine age-at-death by examining various sites on the skeleton. However, due to the fragility of such epiphyseal elements they may be damaged or absent due to various extrinsic factors (e.g. excavation methods and taphonomic processes), which prevents the application of this method to the entire skeleton (Lewis, 2007). Nonetheless, as many sites will be reviewed and compared to the data and summary illustrations provided by Schaefer *et al.,* (2009). Here, age-at-death can be estimated from as early as 5 years till as late as 25 years of age. When appropriate, numerous primary sites of ossification in the non-adult skeleton will be used to determine age-at-death (Schaefer *et al.,* 2009) although, like for epiphyseal union and fusion, care must be taken due to fragile nature of this material.

These methods will be applied to each non-adult from the Poulton Chapel, St. Owen's Church and Norton Priory Collections. An overall assessment of age will then be made to distinguish an accurate assessment of age-at-death for each individual. For frequency and completeness of these individuals, all non-adults will be grouped into smaller age-at-death categories (Foetal, 0 to 0.99 years, 1 to 1.99 years and so on…). However, during statistical analysis, these individuals will be grouped into broader age-at-death categories (0 to 4.99 years, 5 to 11.99 years and, 12 to 17.99 years of age).

3.3.2 Adults

For adults, as many standards and methods as possible should be used when determining age-at-death due to degenerative changes that occur across the skeleton. These are variable between different individuals and populations but also the life history of an individual can affect the rate of skeletal ageing in adults (Buckberry and Chamberlain, 2002). Various research papers on dental attrition have been reviewed (e.g. Velle, 1970; Brothwell, 1981; Lovejoy, 1985; Li and Ji, 1995 and Mays 2002), each of which are population specific. For the purpose of this research, the scoring system developed by Brothwell (1981) will be applied. Brothwell (1981) reviews the dental attrition of the three permanent molars for British populations ranging from the Neolithic to the Medieval period. Brothwell noted that 'the rate of wear in early British populations do not appear to have changed' and produced a data table which shows the correlation of the dental wear patterns into broad age categories from 17 to 45+ years of age.

Analysis of the degeneration of the pubic symphysis surface is considered to be one of the most reliable methods of assessing adult age-at-death when present (Buikstra and Ubelaker, 1994). Todd's scoring system (Todd, 1920) uses 10 age phases ranging from 18 to 50+ years of age however, these are based solely on adult male specimens. This study has been further refined and tested (e.g. Books, 1955; Gilbert and McKern, 1973; Meindl *et al.,* 1985; and Katz and Suchey, 1986) taking into account both sexes and population variability. The development of the Suchey-Brooks scoring system (Brooks *et al.,* 1990) recognises variation and accounts for age variability. However, this was further tested and trailed on documented archaeological material and this method produced variable results (Cox, 2000). Another recurring issue is the preservation of the pubic symphyses in archaeological samples. Due to the anatomical position of this area, this leaves the pubic symphysis vulnerable to possible excavation and weathering damage. This can unfortunately lead to a damaged or incomplete pubic symphyseal surface. Nonetheless, no new method has since been developed or tested and for this reason, the Brooks *et al.,* (1990) method will be used to estimate age-at-death for the collections included in this thesis. This method is broken down into 6 phases with broad age-at-death ranges, ranging from 15 to 87 years of age for males and females.

The auricular surface on the iliac bone is another area of degeneration used for ageing. Lovejoy *et al.,* (1985) derived a chart dividing the assessment into 8 phases. Each phase describes the changes to the auricular surface that corresponds to a specific age range within a spectrum of 20 to 60+ years. Recently, this method has been subjected to review and a revised method by Buckberry and Chamberlain (2002) has since been developed and tested (e.g. Osborne *et al.,* 2004; Mulhern and Jones, 2005; Falys *et al.,* 2006, Rouge-Maillart *et al.,* 2009; and Hens and Belcastro, 2012). In comparison to the pubic symphysis, this joint surface does survive more within archaeological contexts however, this method requires further testing on larger documented archaeological samples as other implications such as mechanical stresses can affect the changes observed on these surfaces (Cox, 2000), essentially affecting the assessment of age-at-death. Lovejoy *et al.,* (1985) method was applied during the early phases of data collection and was maintained throughout data collection for this thesis.

When little material is available, other traits such as the suture closure of the spheno-occipital synchondrosis (Krogman and Iscan, 1986) and other cranial sutures have been used to determine age-at-death in adults (Meindl and Lovejoy, 1985). Also, the sternal end of ribs (Iscan *et al.,* 1984; 1985) can be used. These methods separate individuals into much broader age ranges and will only be applied when necessary.

As many of these methods will be applied to each adult from the Poulton Chapel, St. Owen's Church and Norton Priory Collections. An overall assessment of age will then be made to distinguish an accurate assessment of age-at-death for each individual. As assessment of age-at-death for adult skeletal remains are determined based on degenerative methods, various extrinsic factors can affect this rate of degeneration often leading to the under or over ageing of an individual. For this reason, adults will be grouped into three broad age-at-death categories to cover 'young adult' (18 to 24.99 years), 'middle adult' (25 to 44.99 years) and 'older adult' (45+ years).

3.4 Sex Assessment

Determination of sex in skeletons is normally the result of the analysis of traits in the skull and the pelvis. In any population, male and female skeletons differ in size and shape but there are individuals who do not have the typical, defined characteristics and therefore do not fall into a definite male or female group. Each attribute is normally scored on a '1 to 5' scale, '1' being mostly female and '5' being mostly male, while those scored as '3' are classed as ambiguous (Buikstra and Ubelaker, 1994). The features on the skull and pelvis are quite sexually dimorphic in comparison to other sexing methods. The development of these attributes begins in puberty and continues through growth and with age. An accuracy of 98% can be achieved from using both the skull and the pelvis (Krogman, 1962).

There are several indications of sex on the pelvis and skull but these are reliant upon the completeness of the skeleton (Meindl *et al.,* 1985) as idiosyncratic variation is very common amongst human skeletons. The traits examined include the greater sciatic notch (Walker, 2005), the sub pubic angle (Workshop of European Anthropologists, 1980) the ventral arc (Sutherland and Suchey, 1991), the sub pubic concavity (Rogers and Saunders, 1994) and the ischiopubic ramus ridge (Bruzek, 2002). With regards to the skull, males usually have a larger and more robust skull in comparison to females who tend to be more smooth and delicate. There are five key attributes that generally survive in archaeological contexts, the nuchal crest, the mastoid processes, the supraorbital margin, the supra-orbital ridge, and the mental eminence (Buikstra and Ubelaker, 1994). Other methods apply metrical analysis. The most common metrics used include the maximum diameter of the femoral and humeral heads. These metrics are generally larger in males than females according to data tables produced by Stewart (1979). Similar results have been observed in other skeletal elements (e.g. Berrizbeitia, 1989).

The determination of sex for non-adult remains is more problematic. The identification of the sexually dimorphic markers used in adults is not possible in non-adult remains until the advanced stages of puberty. Research has been developed to aid the determination of sex in non-adult remains (e.g. Mittler and Sheridan, 1992; Franklin *et al,* 2007; Cardoso and Saunders, 2008; and Wilson *et al.,* 2011). However, issues remain surrounding the results. For this purpose, individuals under 18 years of age will not be subjected to sex assessment.

This thesis will only estimate sex for individuals over 18 years of age. These individuals will in turn be classified into the '1 to 5' scoring system using by Buikstra and Ubelaker (1994). Individuals considered as '1' or '2' will be collated to mark the female sample. Individuals who are reported as '3' mark individuals who are considered ambiguous. Finally, individuals considered as '4' and '5' will be collated to mark the male sample for each collection. Unfortunately, due to the completeness or preservation of some adult remains, no skeletal markers used to estimate sex are available for analysis. In these instances, the adult individual is recorded as a '9', which identifies this individual as undetermined sex.

3.5 Stature Assessment

In most populations females are normally smaller than males, but there is much overlap in the distribution of statures among males and females. Therefore, more accurate assessment of stature requires a prior knowledge of the sex of the skeleton. Accuracy can also be improved by including more well-chosen long bones. Long bone lengths are obtained generally using an osteometric board. Bones with post-mortem fractures can be reconstructed before measurement, although it was stated by Collis (2004) that only long bones with a maximum of three post-mortem fractures can be used. However, work has been undertaken for stature reconstruction using fragmentary remains (e.g. Steele *et al.,* 1969; Black, 1978; Simmons *et al*., 1990 and Bidmos, 2008a; 2008b; 2009). The regression formulae developed provide reliable assessment when tested on known skeletal collections. The measurements of the humerus, ulna, radius, femur and fibula are simple to obtain, measuring the maximum length of each element. The tibia is more complex, it is measured at its full length excluding the intercondylar eminence (Trotter and Gleser, 1952). The formula derived from Trotter and Gleser (1952 and 1958) apply the best formula of the bones available for each skeleton. Both left and right sides are calculated, and the result consists of an average so any disparity between the sides can be examined. If sex is undetermined, stature assessment is not attempted. The result is recorded in cm and then in feet and inches (Appendix 4).

It must be noted that stature assessments are not needed for the overall purpose of this thesis and has not been reported to affect NMTs within and between population groups. However, one of the objectives for this thesis is to report the demographics for each collection. The author feels that the overall stature assessment is valuable alongside the age-at death and sex assessments and will be included for completeness.

3.6 Nonmetric Traits

Nonmetric traits are minor morphological variations that can be found across the normal anatomy of a human skeleton. Nonmetric traits are the expressions of variation that can be found within the bones or dentition of a single individual. Such NMTs can include additional sutures, facets, bony processes, tubercles, crests variations in foramina and articular facets and, a range of other features. Over 400 NMTs have been recognised within the human skeleton. However, a reasonably short list of 126 NMTs has been compiled for ease of recording over large skeletal assemblages. These 126 NMTs have been chosen for analysis due to easy identification and, ease of recording with efficiency for fragmented, incomplete and poorly preserved human skeletal remains. Appendix 1 identifies the NMTs considered of primary importance for this research and includes information about their location and scoring method. There are also figures to illustrate these (see Appendix 2).

One hundred and twenty-six NMTs have been selected to be recorded for each individual from the Medieval Poulton Chapel, St. Owen's Church and Norton Priory Collections. This research extrapolates 26 cranial traits from Berry and Berry (1967), 17 postcranial traits from Finnegan (1978) and a further 80 variants from across the skeleton which includes pathological (Barnes, 1994) and minor (Hauser and De Stefano, 1989) variants. These NMTs will be explored collectively and then sub-divided to evaluate NMTs considered to be genetic in origin (n=75), ambiguous in nature (n=29) and those likely associated to activity-related changes (n=22). The classification of each NMT is identified in Appendix 1. Each NMT will be scored as '1' when present, '0' when absent, and '9' when the skeletal material is missing or damaged for taphonomic or pathological changes that the trait cannot be scored. When applicable, bi/unilateral traits will be recorded and whether multiple traits have occurred. As mentioned in the introduction, there are various discussions on how bilateral NMTs should be scored and then subjected to statistical analyses. For some statistical analyses, only one side can be subjected to analysis. Because of this, a decision for which score (left or right) is the left or the right side (Haeussler *et al.,* 1988) while another method suggests to score both sides and to account for asymmetry, count the side with the highest expression (Turner and Scott 1977). Finally, to maximise sample size, if only one side is present, that side is scored and counted (Irish, 2005). Although this method is claimed to underrepresent frequencies of certain NMTs in dental studies (Green *et al.,* 1979) it is the standard protocol for the Arizona State University Dental Anthropology System (Turner *et al.,* 1991; and, Scott and Turner, 1997). This method presumes the maximum expression for a particular NMT is achieved for each individual. Furthermore, these methods have been applied and explored to consider bilateral NMTs of the cranium (Ossenberg, 1981; McGrath, *et al.,* 1984; and Halligrimsson, *et al.,* 2005) and postcranial skeleton (Trinkaus, 1978; and Korey, 1980) each with their own argument to support their own sampling methods. For the purpose of this research, the author will consider the following scores for bilateral traits; '1/1', '1/0', '0/1', '1/9', '9/1', '0/9', '9/0', '0/0' and '9/9'. For this thesis, the side with maximum expression will be subjected to statistical analysis.

For this research, 126 NMTs traits will be examined for each individual from the Poulton Chapel, St. Owen's Church and Norton Priory Collections. Here, 55 of these traits were examined from the crania and 71 from the postcrania. Full descriptions of the anatomy, illustrations and the scoring methodology of each trait can be found in the Appendix (see Appendix 1 and 2). These were developed by the author for ease of use and interpretation.

3.7 Statistical Analysis

The data for this thesis were collected and entered into an Excel datasheet. For the analysis of the data included in this research, the software system SPSS (Statistical Package for the Social Sciences, version 23) was applied. For all analyses, the alpha level was set at $p<0.05$. However, as multiple analyses will be subjected to the same dependent variables (n=126) the number of Type I errors (false positives) will increase. This in turn increases the likelihood of a significant result occurring by chance. In order to correct for this, a Bonferroni correction is required. A Bonferroni correction protects the results from Type I errors. Unfortunately, this leads to an increase in Type II errors (false negatives). Nonetheless, a lower *p*-value is required to make it less likely to commit a Type I error. A Bonferroni corrected *p*-value is adjusted by taking the *p*-value and dividing by the number of tests to be run. For this thesis, the corrected values are as follows: for all 126 NMTs, the corrected *p*-value=0.00039683 (0.05/126). However, these 126 NMTs are subdivided to those considered genetic in origin (n=75) with a corrected *p*-value of 0.00066667 (0.05/75). For NMTs considered to be activity-related (n=22), the corrected *p*-value is 0.00227273 (0.05/22) and, finally, for NMTs considered to be ambiguous in nature (n=29) the corrected *p*-value is 0.00172414 (0.05/29). To determine if any of the results are statistically significant the *p*-value must be less than the value given here.

For this research, recording repeatability must be evaluated. A widely accepted method for assessing repeatability involves conducting intra/inter-observer error at a statistical level. This analysis is to follow a set time interval when the observer re-scores a subsample of the study samples and then compares the two sets of observations. To test the repeatability of data recording for this research, a compilation of 30 NMTs were randomly selected and subjected to intra/inter observer error using the Kappa Cohen's test for repeatability (Landis and Koch's, 1977). A 10% subsample of the human skeletons included in this research were selected for this re-evaluation. The author and four observers were tested for the repeatability of data recording for this research. The author completed her analysis within four weeks of initial data collection. The four observers completed their analysis six to eight weeks after the initial data set was completed. Each observer was provided a copy of the descriptions and illustrations of the scoring methods presented in the Appendix (see Appendix 1 and 2) without further assistance.

The following statistical methods were applied to the dataset of the Poulton Chapel, St. Owen's Church and the Norton Priory Collections. Firstly, a Chi-square test was applied to explore presence and absence of the left and right occurrences of individual NMTs. This analysis of independence compares two variables in a contingency table to see if they are related to one another. It is hopeful that these analyses will identify any side dominance for particular NMTs, specifically those considered to be related to activity. Following this, a Mann-Whitney U Test (a non-parametric test) was applied to compare differences between two independent groups. In this case, comparing between males and females against a categorical dependent variable. These analyses enable the explorations of any differences in the frequency of all 126 NMTs between the sexes. This test will identify if any NMTs are specific in males rather than females, or in females rather than males or highlight if there is no difference at all. Exploring these differences within each sample and then between all samples will prove interesting.

Finally, a Kruskal-Wallis H Test (a rank based non-parametric test) was used to determine if there are any statistical differences between two or more groups of independent variables. This test is an alternative to the Mann-Whitney U Test, which allows a comparison of more than two independent groups (Zar, 20110). The use of the Kruskal-Wallis H Test permits the exploration of any significant statistical differences between the age-at-death categories for each collection. This same test can be applied to explore any differences between the three sample sites. However, it must be noted that the Kruskal-Wallis H Test cannot identify which specific groups of the independent variables are statistically significant from each other. This test only identifies that at least two groups are different. Determining which group differed to each other is important for this research. To reach this goal, a post hoc test was applied. In order to conduct a post hoc test, a one-way ANOVA (ANalysis Of VAriance) was applied. A one-way ANOVA is considered the as an alternative to the Kruskal-Wallis H Test (Zar, 2010) permitting the comparison of more than two independent groups (Zar, 2010; and Griffith, 2010). As previously noted with Kruskal-Wallis H Test, the one-way ANOVA test cannot determine which specific groups were statistically different from each other. Only that at least two groups of dependent groups are different. However, for this test statistic, a Tukey's HSD post hoc test was applied through the one-way ANOVA analyses on this data set. This test can identify which groups are different to each other.

The identification of the category (genetic, ambiguous or activity-related) for each NMT can be found in Appendix 1. For traits that are scored for both left and right sides, the highest score was used as this value shows the maximum expression for that specific NMT (see Chapter 5). Only NMTs recorded as present ('1') or absent ('0') were subjected to statistical analyses. All NMTs recorded as unobservable ('9') will be removed from the analysis. Finally, to explore intra-population analysis, a hierarchical clustering dendrogram (based on average linkage and a squared Euclidean distance dissimilarity coefficient), was applied to each collection (see Chapter 6).

3.8 Inter- and Intra-Population Analysis

An aim of this thesis is to run a population based comparison of the NMT frequency and variation found within and between the Poulton Chapel, St. Owen's Church and Norton Priory Collections. Running the statistical analysis stated in 3.7 will meet the other objectives aimed to explore if age and/or sex of an individual affects the expression of the NMTs observed. By comparing these samples, NMTs considered to be related to activity can be explored for each site. This could provide an insight into any differences between the rural Poulton Chapel and St. Owen's Church Collections. Alongside this, it is hopeful to be able to identify between possible social divides between these two sites and Norton Priory. Nonetheless, the final aim of this thesis is to identify plausible familial relationships using burial spatial distributions within the burial ground of each sample. It is suggested that some NMTs can be used to distinguish between individuals who are closely related within a sample (Pilloud and Larsen, 2011). Those who are likely closely related genetically tend to be buried near one another. This is possible as family members would like to be buried within a certain area and in some instances, certain areas may be reserved for families of a higher status (Daniell, 1998). The foundation of this is objective is that individuals sharing similar traits are thought to be more closely related than those sharing fewer traits. This notion will be explored using Hierarchical Cluster analysis and Burial Spatial Distribution analysis within the cemetery. Finally, these samples will be compared to other skeletal assemblages to see how the fit within other skeletal collections.

3.8.1 Hierarchical Cluster Analysis

This method of exploring possible familial linkages utilises cluster analysis in order to identify sub-groups of individuals bearing similar combinations of NMTs. It is assumed that individuals sharing similar combinations of NMTs are more likely to be closely related than those who share fewer combinations. A hierarchical clustering dendrogram, based on average linkage and a squared Euclidean distance dissimilarity coefficient, builds the hierarchy from individual elements by progressively merging clusters and was applied for this part of the analysis. However, for this analysis, the data of all 126 NMTs is required for each individual. As this data is recorded on a present (1) and absent (0) basis, it is not possible to estimate the missing values (9).

Here, only individuals for whom 126 skeletal variants could be scored as '1' and '0' can be included. This essentially will reduce the sample size for each collection (Chapter 6.1). Nonetheless, these samples will be subjected to hierarchical cluster analysis to identify possible groups of individuals who share similar combinations of skeletal variants for each collection.

3.8.2 Burial Spatial Distribution Analysis

This method of exploring possible familial lineages utilises the burial spatial distribution of individuals sharing similar NMTs within a particular burial ground. This approach could lead to the identification of specific areas of a burial ground dedicated to family groups. For this review, the burial distribution of individuals is explored using ArcGIS. However, the burial location, relative to the surrounding archaeology must be known. Alongside this, a site plan does not highlight the missing skeletal material where crania or other skeletal elements are missing, this essentially reduces the number of individuals that can be included in this review. Unfortunately, the archival records for the St. Owen's Church Collection are minimal at this time so this method will not be applied to this sample. On the other hand, Poulton Chapel have recorded enough burial information to input location data for most of their skeletal collection while the data for the Norton Priory sample is more limited. Burial spatial distributions will be attempted for both the Poulton Chapel and Norton Priory Collections reviewing specific NMTs and combinations of NMTs for possible familial lineages (Chapter 6.2).

3.8.3 Comparative Assemblages

A small part of this thesis aims to review how the Poulton Chapel, St. Owen's Church and Norton Priory Collections fit within Medieval Britain. This permits a population based comparison of NMT frequency between comparative skeletal assemblages across the U.K. Unfortunately, most archaeological reports containing information from human skeletal remains report only a few NMTs and the traits recorded vary between each site (e.g. Holst and Marston, 2004; and Holst *et al.,* 2008). Relatedly, finding comparison data that record many NMTs, a reasonable sample size and are Medieval in origin is challenging. To overcome this issue, all comparative assemblages are derived from collections across the UK and include one collection from North America. These comparative collections range from the Prehistoric to the Medieval period and then through to Modern. Each data set records different NMTs, those that collate with the NMTs recorded in this thesis will be evaluated. A summary of the comparative assemblages is provided here, and the results of these comparisons can be reviewed in Chapter 5.6.

Mays *et al.,* (2007) recorded 33 cranial and 20 postcranial NMTs in 360 adults (combined sexes) from the Wharram Percy Collection, North Yorkshire. However, non-adults were omitted from their study. The Wharram Percy Collection spans a period of approximately 900 years from the first burials in the late 10th Century through to the late 19th Century. Mays detailed skeletal analysis did report further NMTs, specifically those considered pathological in nature (i.e. spinal defects and dental variation) and are included in this comparison. For this collection, 50 NMTs overlapped with the 126 NMTs recorded in this thesis. Berry (1967) examined 33 cranial NMTs in 186 individuals (combined sexes) from the St. Brides Collection, London. Most burials took place in the 17th Century and led into the early 18th Century. Here, 25 NMTs overlapped with the ones reported in this thesis. Another London skeleton collection considered for this thesis is the named Spitalfields Collection. The Spitalfields Collection is comprised of over a thousand individuals. Four hundred of them comprise of the 'Named' Collection with dates of date ranging from the late 15th Century through to the mid-19th Century. Molleson and Cox (1993) present a thorough manuscript of these individuals which includes a brief report on 35 cranial NMTs recorded, 23 of those overlap with these presented in this investigation. The following information was extracted from a PhD thesis, '*a comparative study of osteological material from the north-east of England*' (Anderson, 1989). Anderson reported the frequency of 19 NMTs from seven human skeletal collections, five of which are included here as comparative samples. However, only 18 NMTs overlapped with the 126 NMTs reported in this study. The first collection is from a small Chapel in Hirsel located along the Scottish Borders. Here the burials are dated from the 11th to 13th century. The Jarrow and Monkwearmouth Collections, Newcastle are likely associated with one another dating from the Saxon to the early 16th Century. The Blackfriars Collection, Newcastle, consists of 36 Medieval burials while the final collection is Blackgate, Newcastle. The Blackgate Collection consists of approximately 140 individual's preliminary dates from the Saxon to the early 12th Century. The final comparative sample does not originate from the UK; this sample is derived from the Terry Collection. The Terry Collection is composed of 19th to 20th Century individuals of European and African-American ancestry. Corruccini (1974) reviewed 72 cranial NMTs from 321 individuals. However, only the data from the European individuals were subjected to comparison (n=139). Twenty-two NMTs overlapped with those used in this thesis.

There is a distinct overrepresentation of cranial NMTs in the comparative material available. Possible reasoning behind this conundrum is explored in Chapter 1. Further studies can be considered to explore NMTs on an individual basis. However, this method will not provide useful comparative information required for these analyses. Nonetheless, future work includes an individual review of NMTs within and between populations (see Chapter 7.4). Overall, it was possible to find comparative data for 44% of the NMTs recorded in the Poulton Chapel, St. Owen's Church and Norton Priory Collections. That includes 54.5% cranial and 36.6% postcranial NMTs.

The following chapter reports on the demographics of the Poulton Chapel, St. Owen's Church and Norton Priory Collections in detail. These analyses will permit a wider understanding of the collections regarding population size, age-at-death and ratio between the sexes, mean stature height and the general completeness of the human skeletal remains of these individuals. These analyses will determine the final sample size of each collection that will be subjected to statistical analysis to meet the objectives of this thesis.

Chapter 4 Results Part 1

Site Demographics

The following section presents the demographics of the Medieval Poulton Chapel, St. Owen's Church and Norton Priory Collections. Each skeleton has been examined individually and then collated to generate the results presented here. The percentages reported here are the true prevalence of the data represented. This information has permitted a wider understanding of the collections regarding population size, age-at-death, and the ratio between the sexes, mean stature and general completeness of the remains. Comparisons will be discussed after these analyses (see 4.4).

4.1 The Poulton Chapel Collection

Up to the summer of 2014 excavations, 791 burials have been identified from Poulton Chapel. However, 71 of these skeletons have been recorded as either lost or reburied, which leaves 720 skeletons available for analysis. Six additional skeletons were identified during MNI analysis, presenting a final total of 726 individuals that are available for analysis and included here for the first time. Poulton Chapel has not been fully excavated, and the skeletons recovered so far likely represent only a small portion of the total number of burials, as excavations to the north and east side of the Chapel have been minimal so far (Burrell *et al*., 2013). It has been suggested that this graveyard may contain upwards of 1500 burials (Emery, 2013; pers. comms.). Nonetheless, the individuals presented here should be a representative sample of the Poulton Chapel Collection. Examination of each skeleton was completed at Liverpool John Moores University (n=558), the Poulton Research Project (n=77), and the University of Liverpool (n=91).

For the Poulton Chapel Collection, there is a slightly higher percentage of adult (57.1%) burials in regard to the non-adult (42.9%) burials (see Table 3) which is typical of most Medieval burial grounds with a high juvenile mortality rate (Lewis, 2002; Lewis and Gowland, 2007). Table 3 shows the completeness of all the skeletons. Completeness and preservation rates at Poulton Chapel vary due to a large number of intercutting burials, the soil type and past damage due to ploughing (Burrell *et al.,* 2012; 2013). Consequently, this degree of completeness creates differential variability between skeletons in the data that can be recovered. Here, there is a slight difference between the completeness of the adult skeletons by sex. However, 84.3% of adults of undetermined sex have a remarkably low level of completeness, which is probably why the sex and/or age-at-death of these individuals cannot be determined (see Table 4).

Table 3: Completeness of all skeletons from Poulton Chapel

		<25%		25-50%		50-75%		>75%		
	n	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**Total (%)**
Non-adults	311	94	30.2	67	21.5	43	13.9	107	34.4	**42.9**
Adults	415	146	35.4	74	17.7	45	10.9	150	36.0	**57.1**
Total	**726**	**240**	**33.1**	**140**	**19.3**	**88**	**12.2**	**256**	**35.4**	**100**

n=Number of individuals

Table 4: Completeness of the sexed adult skeletons from Poulton Chapel

		<25%		25-50%		50-75%		>75%		
	n	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**Total (%)**
Males	190	62	32.9	32	16.5	21	11.3	75	39.3	**45.5**
Females	187	52	27.8	37	19.8	24	12.8	74	39.6	**45.3**
Undetermined	38	32	84.3	5	13.1	0	0	1	2.6	**9.2**
Total	**415**	**146**	**35.4**	**74**	**17.7**	**45**	**10.9**	**150**	**36.0**	**100**

n=Number of individuals

Interestingly, there is almost an even divide between the total number of males (n=190) and females (n=187) at Poulton Chapel. Typically, in the archaeological record, there are more males than females recorded in skeletal collections from archaeological sites (Weiss., 1972; Walker *et al.,* 1988; and Bello *et al.,* 2006). However, population variability and occupations of a given community can affect the results seen. On the other hand, it has been suggested that life expectancy rates of females are considerably shorter due to child bearing (Sessaman, 1993). Currently, no burials at Poulton Chapel have been found with a foetus *in utero*. Nonetheless, Brothwell (1972) and Russell (1958) suggest that the proportions of males to females are roughly equal with a slight predominance of males for most archaeological collections, as seen here within the Poulton Chapel Collection.

The rate of completeness was further reviewed by age. Overall, non-adults are reasonably well preserved with only 30.2% of all non-adults are less than 25% complete. These are more heavily leant towards non-adults under the age of three and upon closer review, for individuals under the age of one (see Table 5). This is probably due to the fragile nature of such young remains, with similar occurrences within most archaeological collections (Gordon and Buikstra, 1981; Walker *et al.,* 1988; and Bello *et al.,* 2006). However, environmental factors of the site could heavily affect this, and the treatment of non-adult burials is just as important. At Poulton Chapel, there is a high concentration of non-adult burials located at the south-east corner of the Chapel (Burrell *et al*., 2012; 2013). This concentration could potentially expose the non-adults to more taphonomical processes than those seen across the rest of the burial ground due to the general stratigraphy of the site (i.e. the level of the water table, drain and boundary ditches). This aspect is currently under review by Davenport *et al*., (2014).

Table 5: Completeness of the non-adults from Poulton Chapel by age-at-death assessment

		<25%		25-50%		50-75%		>75%		
Age (Years)	**n**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**Total (%)**
0 to 0.99	42	16	38.1	12	28.6	6	14.3	8	19	**13.5**
1 to 1.99	15	4	26.7	4	26.7	2	13.3	5	33.3	**4.9**
2 to 2.99	30	10	33.3	5	16.7	7	23.3	8	26.7	**9.6**
3 to 3.99	16	3	18.8	5	31.2	0	0	8	50	**5.1**
4 to 4.99	38	7	18.4	8	21.1	7	18.4	16	42.1	**12.2**
5 to 5.99	1	0	0	0	0	1	0	0	100	**0.3**
6 to 6.99	42	12	28.6	11	26.2	4	9.5	15	35.7	**13.6**
7 to 8.99	22	7	31.8	6	27.3	3	13.6	6	27.3	**7.1**
9 to 11.99	55	11	20	12	21.8	6	10.9	26	47.3	**17.7**
12 to 14.99	18	4	22.2	1	5.6	4	22.2	9	50	**5.8**
15 to 17.99	16	4	25.1	3	18.7	3	18.7	6	37.5	**5.1**
Undetermined	16	16	100	0	0	0	0	0	0	**5.1**
Total	**311**	**94**	**30.2**	**67**	**21.6**	**43**	**13.8**	**107**	**34.4**	**100**

n=Number of individuals

Table 6: Completeness of the adults from Poulton Chapel by age-at-death assessment

		<25%		25-50%		50-75%		>75%		
Age (Years)	**n**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**Total (%)**
18 to 24.99	39	11	28.2	3	7.7	2	5.1	23	59.0	**9.4**
25 to 44.99	161	21	13.0	36	22.4	24	14.9	80	49.7	**38.7**
45+	109	22	20.2	23	21.1	17	15.6	47	43.1	**26.3**
Undetermined	106	92	86.8	12	11.3	2	1.9	0	0	**25.6**
Total	**415**	**146**	**35.3**	**74**	**17.7**	**45**	**10.9**	**150**	**36.1**	**100**

n=Number of individuals

On the other hand, the adults are reasonably complete (see Table 6) with similar numbers across the age categories. However, 35.3% (n=146) of individuals are less than 25% complete, and 92 of these individuals (86.8%) are of undetermined age. It is important to consider what effects the burial environment has on the preservation and completeness of the human skeletal remains, specifically those elements used for analysis of age and sex (Davenport *et al.,* 2014). Because of this, the high frequency of undetermined individuals could affect the overall demographic profile of this population, and similar issues have been recorded at other archaeological sites (e.g. Brothwell, 1972; Gordon and Buikstra, 1981; Walker, 1995; and Bello *et al*., 2006). For this reason, the subsequent analysis will only consider individuals with an assigned age and/or sex assessment (n=602).

The summary analysis for all individuals with an estimated age-at-death (n=602) can be seen in Figure 16. For most archaeological collections, it is typical to see a higher occurrence of infant deaths in relation to the adults as children are more susceptible to acute infection and disease than adults (Lewis, 2002; and Lewis and Garland, 2007). This is evident in the Poulton Chapel Collection. Currently, the non-adults account for just under half of the collection resembling the Wharram Percy Collection (Mays *et al*., 2007). However, the Poulton Chapel Collection may exceed this as excavations are still ongoing.

Figure 16: Age-at-death assessment for all individuals from Poulton Chapel

The adult sample was categorised further by their sex assessment (see Figure 17). Figure 17 highlights the sex distribution between the age-at-death categories for the Poulton Chapel adults (n=307). Osteological reports regularly record a higher frequency of women at a younger age than the men (Sullivan, 2004; DeWitte, 2010; Green, 1989; Brothwell, 1972; and Wells, 1975). Because of this, it has often been assumed that this is due to the hazards of pregnancy and childbirth especially in smaller communities with more rudimentary obstetric skills (Johnson, 2016; DeWitte, 2010; Green 1989; and, Wells, 1975**)**. It is difficult to say whether this is the case for the women buried at Poulton Chapel as a burial of a female with child has not been acknowledged at this point. Regardless, similar numbers are retained between the sexes for the other age-at-death categories. Overall, these age-at-death assessments must be taken with care and consideration as age-related changes are highly influenced by a variety of factors that could be genetic, dietary, activity-related and epidemiological. Also, the preservation of the skeletal material will permit variations in the methods applied to each individual within this collection.

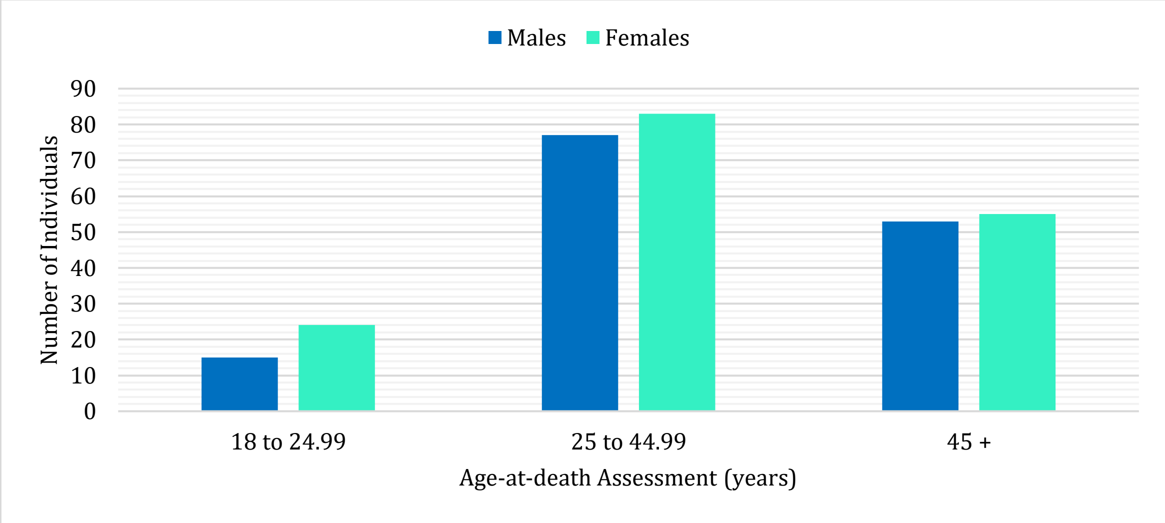

Figure 17: Age-at-death and sex assessment of the Poulton Chapel adults

Stature assessment was applied to 240 of the adults at Poulton Chapel where complete long bones were available, and the sex of the individual could be determined. Stature was not attempted for the non-adult sample. Figure 18 presents the height distributions of the males and females from Poulton. The average height for males and females can be seen in Table 7. These individuals fall within the typical range of height for medieval adults (Caffell, 1997; Carrot *et al.,* 2004; and Holst and Marston, 2004). The Poulton Chapel males sit slightly below the recorded mean of 170.5cm whereas the females fall slightly above the representative average of 158.6cm.

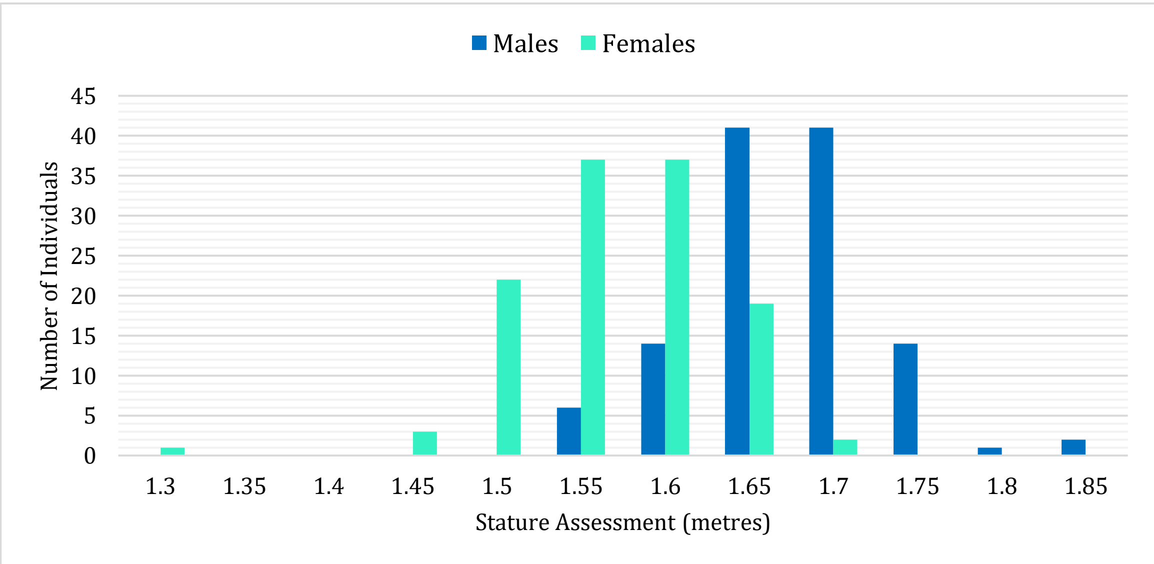

Figure 18: Stature assessment of the adults from Poulton Chapel

Table 7: Average height of the adults from Poulton Chapel

Sex Assessment	n	Mean	Range
Male	119	169.8cm, 5ft 7in	155.2 – 186.3cm
Female	121	159.5cm, 5ft 3in	131.1 – 174.1cm

n=Number of Individuals

4.2 The St. Owen's Church Collection

The St. Owen's Church Collection is made up of two series of excavations from St. Owen's Church, Gloucester in association with the Bristol and Gloucester Archaeological Society. The first excavation took place in 1983 (n=71) and the second in 1989 (n=225) where multiple burials were identified and exhumed. Collectively, there are 296 individuals available for analysis and are included here. As this collection is housed at Liverpool John Moores University, the examination of each individual was conducted here.

Unlike the Poulton Chapel Collection, there is a much higher concentration of adult (67.6%) burials compared to the number of non-adult (32.4%) burials (see Table 8). This is unusual as juvenile mortality rate is typically high within Medieval burial grounds (Lewis, 2002; and Lewis and Gowland, 2007). Alternatively, it has been suggested that children may have been treated differently in burial and possibly buried at a different location. It is uncertain whether this is the case for this skeletal collection as St Owen's Church has only been partially excavated. However, this burial ground is within close proximity to St. Mary De Crypt, Blackfriars, Greyfriars, and London Road, each of which could hold other burials from this community. It has been noted that some burials were interred at St. Mary De Crypt from 1646 onwards (see Chapter 2) although this site has not been subjected to archaeological investigation.

Table 8 shows the completeness of all the skeletons from St. Owen's Church. Like Poulton Chapel, there is a reasonably high occurrence of intercutting between the burials which are reflected in the rate of completeness. However, the preservation of the remains is of lower quality. This is probably due to the soil chemistry and burial environment that vary between and even within burial grounds (Buckberry, 2000; and Jans *et al.,* 2002). Regardless, this varying degree of completeness creates variability between skeletons and the data that can be recovered from them. There is a slight difference between the completeness of the adult skeletons by sex. However, 91.7% of adults of undetermined sex have a remarkably low level of completeness, likely the reason as to why the sex and/or age of death of these individuals cannot be determined (see Table 9).

There is a slightly higher occurrence of the total number of male burials (n=104) than females (n=84) at St. Owen's Church. This is typical of the archaeological record (Mays *et al.*, 2007; and Vincent and Mays, 2009). As highlighted earlier, there are usually more males than females recorded in skeletal collections from archaeological sites (Weiss., 1972; Walker *et al.,* 1988; and Bello *et al.,* 2006), as the anatomy of males tends to be more robust that of females. It is also dependent on the lifestyles and occupations of a given community. For example, communities that are heavily relevant on men working away from home (i.e. for trade and/or battle) may lead to a distortion in the numbers recorded (Holst and Marston, 2004). On the other hand, Pearson (1993) suggests some inhumations can be divided by sex within the burial ground. However, preliminary review of the burial distribution for the St. Owen's Church Collection does not support this and as St. Owen's Church is only partially excavated, it is likely that the "missing dead" are affecting the results presented, creating a bias between the sexes.

Table 8: Completeness of all skeletons from St. Owen's Church

		<25%		25-50%		50-75%		>75%		
	n	**n**	**%**	**N**	**%**	**n**	**%**	**n**	**%**	**Total (%)**
Non-adults	96	17	17.7	29	30.2	26	27.1	24	25	**32.4**
Adults	200	47	23.5	62	31	52	26	39	19.5	**67.6**
Total	**296**	**64**	**21.6**	**91**	**30.7**	**78**	**26.4**	**63**	**21.3**	**100**

n=Number of individuals

Table 9: Completeness of the sexed adult skeletons from St. Owen's Church

		<25%		25-50%		50-75%		>75%		
	n	**N**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**Total (%)**
Males	104	25	24.1	29	27.9	33	31.7	17	16.3	**52**
Females	84	11	13.1	32	38.1	19	22.7	22	26.1	**42**
Undetermined	12	11	91.7	1	8.3	0	0	0	0	**6**
Total	**200**	**47**	**23.5**	**62**	**31**	**52**	**26**	**39**	**19.5**	**100**

n=Number of individuals

The rates of completeness were further analysed by age assessment. Overall, the non-adults are reasonably well preserved with only 17.7% of all non-adults at less than 25% complete. Through closer review, 54.4% of these individuals are non-adults under the age of 3 years with 26.7% at no more than one year of age (see Table 10). Like Poulton Chapel, this is probably due to the fragile nature of non-adult skeletal remains and is similar amongst most archaeological collections (Gordon and Buikstra, 1981., Walker *et al*., 1988; and Bello *et al*., 2006). Unfortunately, there is little information within the archives, and only summary reports of the excavations remain.

On the other hand, the adults are reasonably complete (see Table 11) with similar numbers across the age categories. However, 23.5% (n=47) of all individuals are less than 25% complete with 23 of these are of undetermined age (76.7%). As mentioned earlier, it is important to take into consideration the effects of the burial environment on the preservation of the skeletal remains. This high frequency of undetermined individuals could affect the overall demographic profile of a population where similar issues have been recorded within other archaeological skeletal collections (e.g. Brothwell, 1972; Gordon and Buikstra, 1981; Walker, 1995; and Bello *et al.*, 2006). Because of this, the subsequent part of the analysis will only consider individuals with an assigned age and/or sex assessment (n=265).

Table 10: Completeness of the non-adults from St. Owen's Church by age-at-death assessment

		<25%		25-50%		50-75%		>75%		
Age (Years)	**n**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**Total (%)**
0 to 0.99	15	4	26.7	3	20	3	20	5	33.3	**15.6**
1 to 1.99	13	1	7.7	6	46.1	3	23.1	3	23.1	**13.5**
2 to 2.99	15	3	20	7	46.7	2	13.3	3	20	**15.6**
3 to 3.99	4	0	0	1	25	2	50	1	25	**4.2**
4 to 4.99	10	1	10	2	20	6	60	1	10	**10.4**
5 to 5.99	9	1	11.1	3	22.3	2	33.3	3	22.3	**9.3**
6 to 6.99	4	1	25	1	25	1	25	1	25	**4.2**
7 to 8.99	7	2	28.6	2	28.6	2	28.6	1	14.2	**7.3**
9 to 11.99	4	1	25	2	50	1	25	0	0	**4.2**
12 to 14.99	7	0	0	2	28.6	1	14.2	4	57.2	**7.3**
15 to 17.99	7	2	28.6	0	0	3	42.8	2	28.6	**7.3**
Undetermined	1	1	100	0	0	0	0	0	0	**1.1**
Total	**96**	**17**	**17.7**	**29**	**30.2**	**26**	**27.1**	**24**	**25**	**100**

n=Number of individuals

Table 11: Completeness of the adults from St. Owen's Church by age-at-death assessment

		<25%		25-50%		50-75%		>75%		
Age (Years)	**n**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**Total (%)**
18 to 24.99	19	3	15.8	6	31.6	5	26.3	5	26.3	**9.5**
25 to 44.9	92	15	16.3	40	39.1	25	27.2	16	17.4	**46**
45+	59	9	15.3	14	23.7	21	35.6	15	25.4	**29.5**
Undetermined	30	23	76.7	6	20	1	3.3	0	0	**15**
Total	**200**	**47**	**23.5**	**62**	**31**	**52**	**26**	**39**	**19.5**	**100**

n=Number of individuals

The summary analysis for all individuals with an estimated age-at-death (n=265) can be seen in Figure 19. For most archaeological collections, it is typical to see a higher occurrence of infant deaths in relation to the adults as children are more susceptible to acute infection and disease than adults (Lewis, 2002; and Lewis and Garland, 2007) and this is evident within the St. Owen's Church Collection. Like Poulton Chapel, there is a remarkably high peak of non-adults under the age of three (16.4% of the population). However, there is a distinct drop in the number of non-adults aged between three to eight years and this is followed by another drop and remains steady until 17 years of age. This resembles patterns recorded in other archaeological collections with such high infant mortality rates (Goodman and Armelagos, 1989; and Chamberlain, 2006). Goodman and Armelagos (1989) suggest there is a relationship between the type of infections seen and age in non-adult remains. Most lesions are typically seen earlier on in life, particularly within the first year, with a second peak in the five to ten year category. This is expected of children as they are more vulnerable to infection and disease. Non-adults who survive these pathogens leave a scar that permits the analysis of various pathologies such as porotic hyperostosis, periostitis, cribra orbitalis, and enamel hypoplasia. These can be recorded, and the prevalence can be analysed within and between collections. Preliminary results by Dove *et al*., (2014) suggest that there is a higher prevalence of infection and disease within the St. Owen's Church Collection than those from Poulton Chapel.

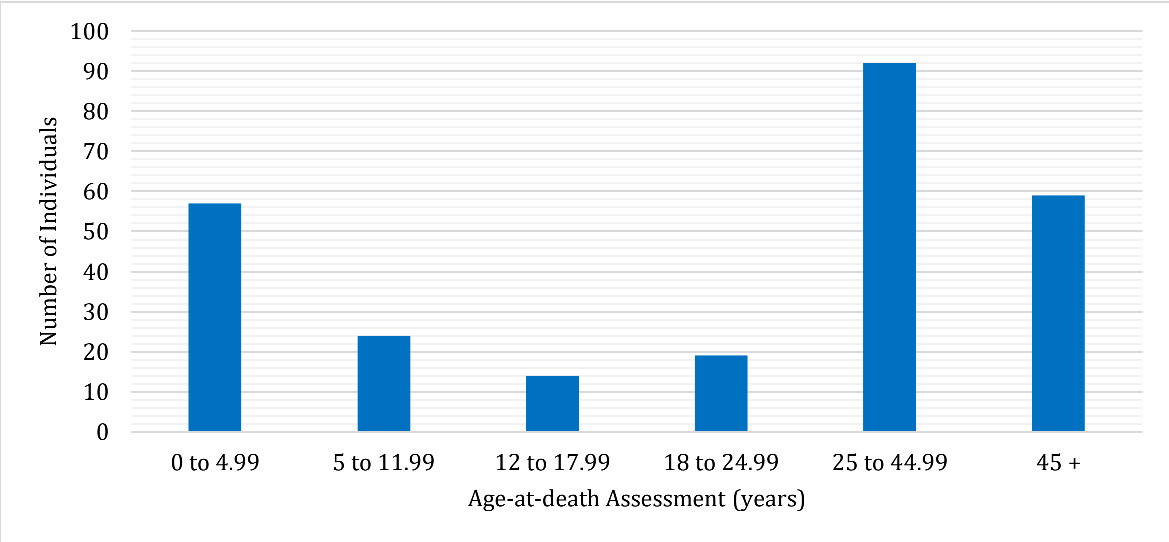

Figure 19: Age-at-death assessment for all individuals from St. Owen's Church

The age-at-death assessments for adults were analysed further by their assessment of sex (see Figure 20). Figure 20 highlights the sex distribution between the age categories for the St. Owen's Church adults (n=170). Here, there is a distinct contrast in the total number of males and females for the 18 to 24 and the 25 to 29 estimated age-at-death categories. Those who lived in urban areas such as Gloucester have a predisposition to much harsher environments than their rural counterparts (Kowaleski, 1988). Osteological reports regularly record a higher frequency of women at a younger age than the men as it has often been assumed that this is due to the hazards of pregnancy and childbirth (Johnson, 2016; DeWitte, 2010; Green 1989; and, Wells, 1975). This could be the case for St. Owen's Church Collection. Unfortunately, archival information surrounding contemporary burials and burial distribution is yet to be reviewed. These age-at-death assessments must be taken with care and consideration as age-related changes are highly influenced by a variety of factors that could be genetic, dietary, activity-related and epidemiological.

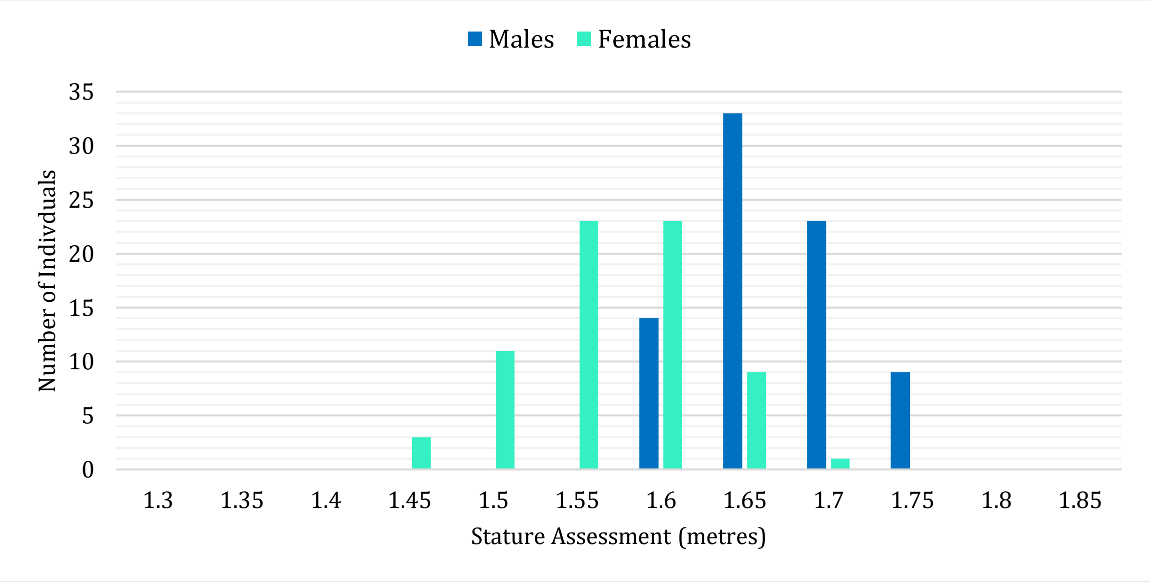

Figure 20: Age-at-death and sex assessment of the St. Owen's Church adults

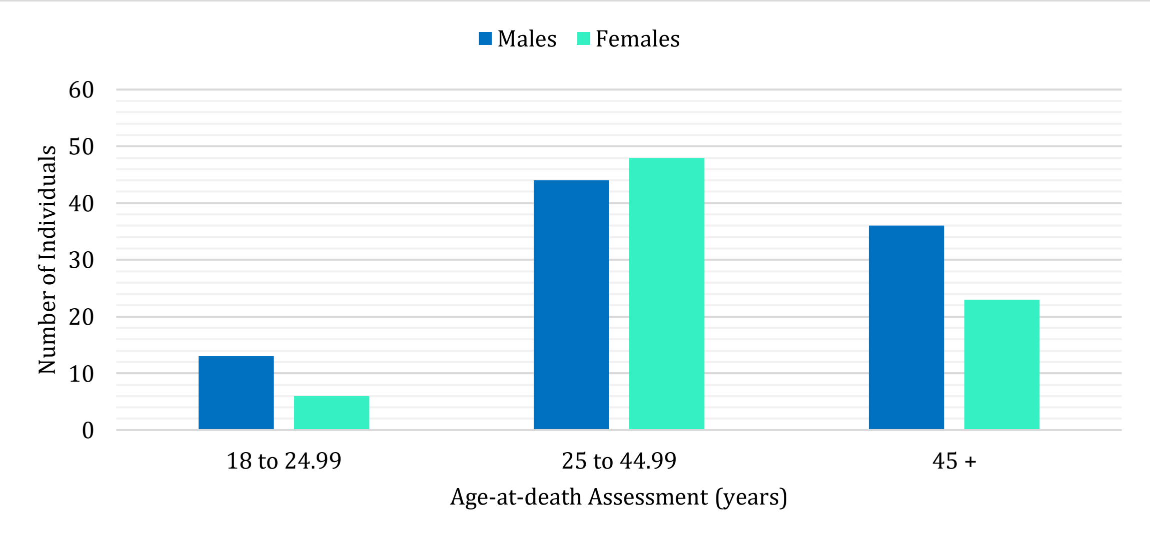

Figure 21: Stature assessment of the adults from St. Owen's Church

Stature assessment was applied to 149 of the adults at St. Owen's Church where complete long bones were available, and the sex of the individual could be determined. Stature was not attempted for the non-adult sample. Figure 21 presents the height distributions of the males and females from St. Owen's Church. The average height for males and females can be seen in Table 12, falling within the typical range of height for medieval adults (Caffell, 1997; Carrot *et al.*, 2004; and Holst and Marston, 2004).

Table 12: Average height for the adults from St. Owen's Church

Sex Assessment	n	Mean	Range
Male	79	169.3cm, 5ft 7in	161.3cm – 179.8cm
Female	70	159.7cm, 5ft 3in	145.2cm – 177.7cm

n=Number of individuals

4.3 The Norton Priory Collection

The Norton Priory Collection comprises of 128 individuals that are available for osteological analysis. During MNI analysis, an additional 37 individuals were identified, five from a charnel deposit and a further five of whom were identified from a second charnel deposit deposited on top of an underlying burial. Here, a total of 165 individuals were subjected to analysis and are included here. Majority of these individuals were examined at the facilities of Norton Priory Museum and Gardens (N=138) the rest were analysed at Liverpool John Moores University (n=27).

For the Norton Priory Collection, there is a much higher prevalence of adult burials (89.1%) in relation to the non-adult burials (10.9%) see Table 13. This low number of non-adult burials cannot be compared to the typical infant mortality profiles seen at other medieval sites. Interestingly, Brown and Howard-Davis (2008) suggest that only privileged families can bury their children in the ground of Norton Priory. Table 13 shows the overall completeness of the skeletons at Norton Priory. Unlike Poulton Chapel and St. Owen's Church, there is very little intercutting between the burials as most burials were exhumed from varying types of coffin burials (see Chapter 2). Because of this, most individuals were protected. However, some burials have been previously disturbed and overlaid within other burials or cut/laid into walls. Here, 29.1% of all individuals are less than 25% complete which introduces variability in the amount of information that can be recorded. There is a slight difference between the completeness of the adult skeletons by sex with 93.3% of adults of undetermined sex have a low level of completeness. This is probably the reason why the sex and/or age of death of these individuals cannot be determined (see Table 14). Unique for the collections reviewed so far; the Norton Priory Collection displays a much stronger prevalence in the total number of male burials (n=100) in comparison to the females (n=36) (see Table 14). This supports previous records of other skeletal collections from archaeological sites, especially for monastic sites (Knüsel *et al.*, 1995; 1997).

Table 13: Completeness of all skeletons from Norton Priory

		<25%		25-50%		50-75%		>75%		
Age (Years)	**n**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**Total (%)**
Non-adults	18	6	33.3	3	16.7	3	16.7	6	33.3	**10.9**
Adults	147	42	28.6	33	22.4	33	22.4	39	26.5	**89.1**
Total	**165**	**48**	**29.1**	**36**	**21.8**	**36**	**21.8**	**45**	**27.3**	**100**

n=Number of individuals

Table 14: Completeness of the sexed adult skeletons from Norton Priory

		<25%		25-50%		50-75%		>75%		
Age (Years)	**n**	**N**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**Total (%)**
Males	100	21	21	21	21	26	26	32	32	**68**
Females	32	7	21.8	11	34.4	7	21.8	7	21.8	**21.8**
Undetermined	15	14	93.3	1	0.7	0	0	0	0	**10.2**
Total	**147**	**42**	**28.6**	**33**	**22.4**	**33**	**22.4**	**39**	**26.5**	**100**

n=Number of individuals

Overall, the non-adults are reasonably well preserved with only 33.3% of all non-adults at less than 25% complete. These are more heavily leant towards non-adults under the age of three and upon closer review, for individuals under the age of one year (see Table 15). This is probably due to the fragile nature of non-adult skeletal remains, and this is similar for most archaeological collections (Gordon and Buikstra, 1981., Walker *et al*., 1988; and Bello *et al*., 2006). The adults are reasonably complete (see Table 16) with similar numbers across the age categories. However, 28.6% (n=42) of individuals are less than 25% complete, and 24 of these are of undetermined age (92.3%). This high frequency of undetermined individuals could affect the overall demographic profile of this population, and similar issues have been recorded at other archaeological sites (e.g. Brothwell, 1972; Gordon and Buikstra, 1981; Walker, 1995; and Bello *et al*., 2006). For this reason, the subsequent part of this thesis will only consider individuals with an assigned age and/or sex assessment (n=130).

Table 15: Completeness of the non-adults from Norton Priory by age-at-death assessment

		<25%		25-50%		50-75%		>75%		
Age (Years)	**n**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**Total (%)**
0 to 0.99	3	1	33.3	1	33.3	0	0	1	33.3	**16.7**
1 to 1.99	0	0	0	0	0	0	0	0	0	**0**
2 to 2.99	2	0	0	1	50	0	0	1	50	**11.1**
3 to 3.99	0	0	0	0	0	0	0	0	0	**0**
4 to 4.99	2	0	0	1	50	1	50	0	0	**11.1**
5 to 5.99	0	0	0	0	0	0	0	0	0	**0**
6 to 6.99	1	0	0	0	0	0	0	1	100	**5.5**
7 to 8.99	2	0	0	0	0	1	50	1	50	**11.1**
9 to 11.99	2	2	100	0	0	0	0	0	0	**11.1**
12 to 14.99	2	1	50	0	0	0	0	1	50	**11.1**
15 to 17.99	2	0	0	0	0	1	50	1	50	**11.1**
Undetermined	2	2	100	0	0	0	0	0	0	**11.1**
Total	**18**	**6**	**33.3**	**3**	**16.7**	**3**	**16.7**	**6**	**33.3**	**100**

n=Number of individuals

Table 16: Completeness of the adults from Norton Priory by age-at-death assessment

		<25%		25-50%		50-75%		>75%		
Age (Years)	**n**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**Total (%)**
18 to 24.99	5	1	20	1	20	0	0	3	60	**3.3**
25 to 44.99	69	8	11.6	13	18.8	20	29	28	40.6	**47**
45+	47	9	19.1	17	36.2	13	27.7	8	17	**32**
Undetermined	26	24	92.3	2	7.7	0	0	0	0	**17.7**
Total	**147**	**42**	**28.6**	**33**	**22.4**	**33**	**22.4**	**39**	**26.5**	**100**

n=Number of individuals

The summary analysis for all individuals with an estimated age-at-death (n=130) can be seen in Figure 22. For most archaeological collections, it is typical to see a higher occurrence of infant deaths in relation to the adults as children are more susceptible to acute infection and disease than adults (Lewis, 2002; and Lewis and Garland, 2007). This is evident in the Norton Priory Collection. Here, there is a distinct peak for the number of non-adult burials under the age of three. Interestingly, this includes the remains of a foetus found *in utero* of a young female. Through metric analysis, it has been estimated that this foetus had attained an age of 36 weeks of gestation (Fazekas and Kosa, 1978). Even with such a small sample size of non-adults (n=18), Figure 22 suggests a high infant mortality rate frequently seen within most archaeological collections (Goodman and Armelagos, 1989; and Chamberlain, 2006).

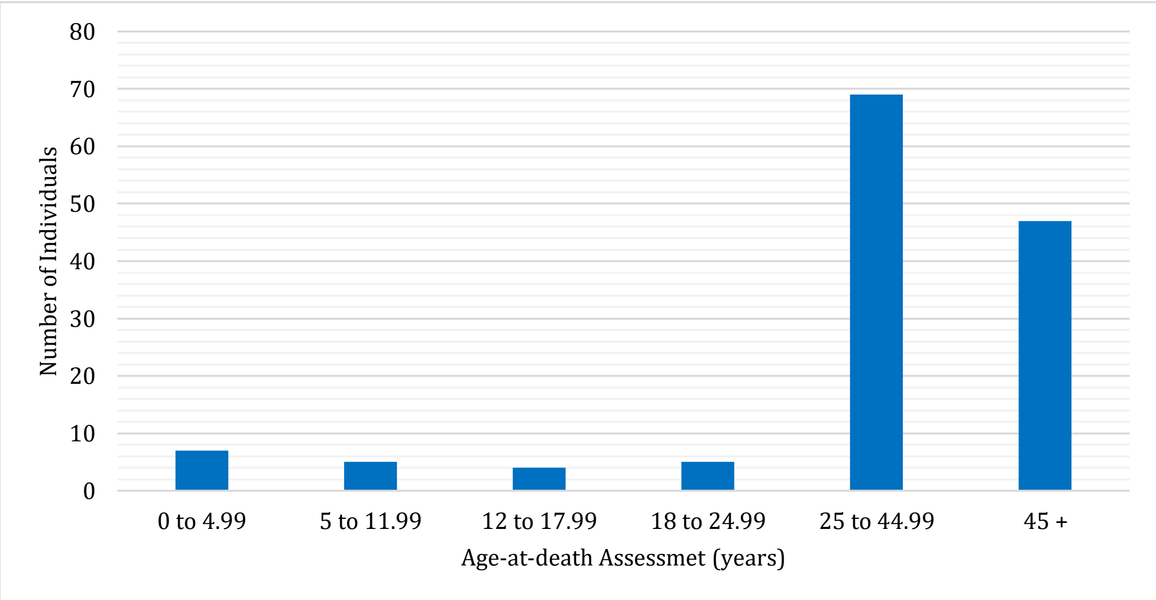

Figure 22: Age-at-death assessment for all individuals from Norton Priory

The adults were reviewed further by their assessment of sex (see Figure 23). Figure 23 highlights the sex distribution between the age categories from Norton Priory adults (n=114). The results presented here are heavily biased towards males with a distinct peak between 35 to 39 years of age. On the other hand, there is a higher proportion of females aged between 18 to 29 years. It has often been suggested that this higher frequency of women in the younger age categories has often been assumed that this due to the hazards surrounding pregnancy and childbirth (Johnson, 2016; DeWitte, 2010; Sullivan, 2004; Green 1989; Wells, 1975 and Brothwell, 1972). At Norton Priory, a young female estimated to be 25 to 29 years of age was found with a foetus *in utero*. This premature death is probably due to complications surrounding late pregnancy (Brown and Howard-Davis, 2008) such as pre-eclampsia or high blood pressure. This is an exceptional case, and further work is being pursued for the other females to see if there is any evidence of skeletal trauma possibly associated with pregnancy. As for all archaeological collections, these age-at-death assessments must be taken with care. As age-related changes are highly influenced by a variety of factors that could be genetic, dietary, activity-related and epidemiological. Also, the preservation of the skeletal material will permit variations in the methods applied to each individual within this collection.

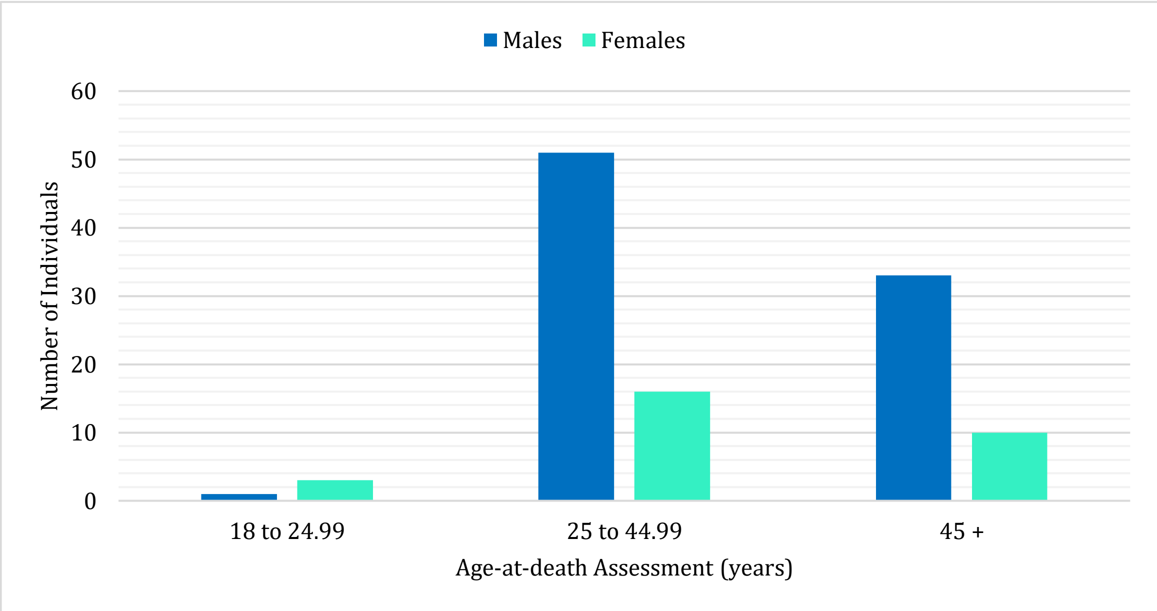

Figure 23: Age-at-death and sex assessment of the Norton Priory adults

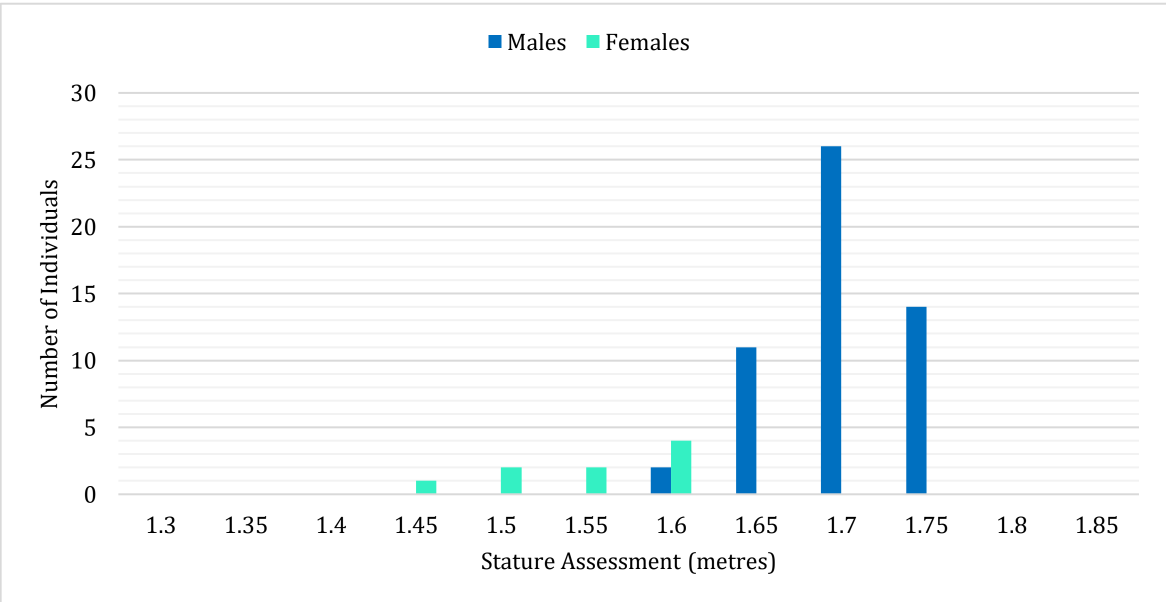

Figure 24: Stature assessment for the Norton Priory adults

Stature assessment was applied to 62 of the adults at Norton Priory where complete long bones were available, and the sex of the individual could be determined. Stature assessment was not attempted for the non-adult sample (see Chapter 3). Figure 24 presents the height distributions of the males and females from Norton Priory with the average height reported in Table 17. These individuals fall within the typical range of height for medieval adults (Caffell, 1997; Carrot *et al.,* 2004; and Holst and Marston, 2004). The mean stature for males at Norton Priory slightly exceeds the documented average of 170.5cm. However, the mean stature for females just falls below the recorded mean of 158.6cm.

Table 17: Average height for the Norton Priory adults

Sex Assessment	N	Mean	Range
Male	53	172.4cm 5ft 8in	161.6 – 179.7cm
Female	9	157.4cm, 5ft 2in	147.8 – 164.0cm

n=Number of individuals

4.4 Reflection of the Demographic Analysis

The demographics of the Poulton Chapel, St. Owen's Church and the Norton Priory Collections provide an insight to just a segment of the people that once occupied these communities. One of the main limitations to any research conducted on these skeletal remains is the partial excavations of the burial ground from which they came. Excavations at St. Owen's Church and Norton Priory are now closed and are incomplete. However, the excavations at Poulton Chapel are still ongoing. At Poulton Chapel, there is still a substantial area to the north and east sides of the Chapel that is waiting to be excavated. Acknowledging the number of burials already excavated from the West and Southern part of the Chapel, there is likely a significant amount of work to be done for the remaining unexcavated areas. As only a portion of the original buried population from Poulton Chapel, St. Owen's Church and Norton Priory is now available for analysis, there may be bias in the paleodemographic and palaeopathological analysis. Further consideration must be made to the fragmentary nature of skeletal remains, especially those of children and women (Bello *et al.,* 2006). As there is a quite a high occurrence of individuals who are less than 25% complete (n=352). For example, some individuals are either a skull only or a set of lower legs and feet. Here, some information can be extrapolated for the skeletal material present. However, when bone preservation is so poor, there is very little identifiable material available for any analysis, in turn, affecting the overall paleodemographics of these sites. It must be kept in mind that this is a common occurrence throughout archaeology and not only limited to these sites (Gordon and Buikstra, 1981., Walker *et al*., 1988; Bello *et al.,* 2006; Mays *et al.,* 2006; Holst *et al.,* 2008, Vincent and Mays 2009; and Cottage and Wilton, 2011).

Here, a total of 1,187 individuals have been examined thoroughly. Due to the nature of the subsequent chapter, the age and sex of an individual must be established, and only 997 individuals fit within these criteria (non-adults, n=406; adults, n=571; grouped as male, n=323; and female, n=268). Like most archaeological collections from the Medieval period, each have a high infant mortality rate with a slight increase for the young non-adults followed by a steady path until young adulthood. Figure 25 groups the adults into broad age-at-death categories for the three samples (18 to 24.99 years, 25 to 44.99 years and 45+ years).

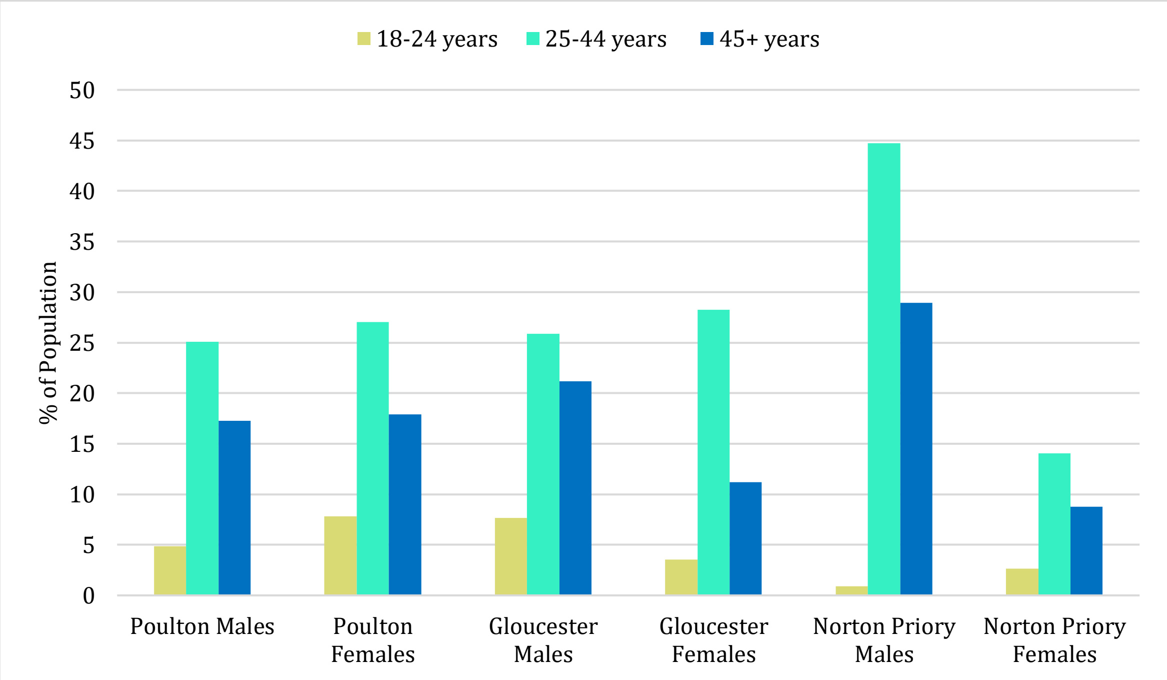

Figure 25: Age-at-death assessment for the adults for each site

It must be highlighted that it is difficult to validate age-at-death assessments for adult remains in archaeological populations. It is often noted that when testing skeletal and dental methods on known age populations (e.g. the named Spitalfields and the Todd Collections) significant discrepancies have been shown leading to younger individuals being assigned older age categories and older individuals appear younger. The assessment of dental formation and eruption, and, bone growth and development in the non-adults lead to reasonably accurate age-at-death assessments. However, this is more problematic for adult individuals (Aykroyd *et al.,* 1999) as numerous extrinsic factors can lead to different rates of degeneration between individuals. For example, diet, disease and physical activity can all affect how slow or fast a skeleton can age, and each can often lead to under or over ageing of an adult individual. The life history of an individual can vary with a site and between populations from different sites

(Buckberry and Chamberlain, 2002). Numerous methods of adult age assessment have been tried-and-tested to determine the age distributions for different population groups (see 3.4) although, at this point, none of the current methods of skeletal age assessment can provide accurate levels of age assessment with any precision. As there are no narrow or precise age-at-death categories observed in these methods, this thesis, like most research concerning adult age-at-death assessments, the adults have been grouped into three broad age-at-death categories. This method of categorisation has likely resulted in the peak observed for the 'middle adults' (25-44 years) seen in Figure 25. This is likely an artefact of age-at-death methods applied to unknown archaeological remains.

Regarding stature assessments for the adults, Poulton Chapel and St. Owen's Church are remarkably similar in their average height for males and females. Norton Priory is slightly outside the range of similarity (Table 18). The typical average height recorded for Medieval adults is 170.5cm for males and 158.6cm for females (Caffell, 1997; Carrot *et al.,* 2004; and Holst and Marston, 2004).

Table 18: Average height for the adults from Poulton Chapel, St. Owen's Church & Norton Priory

	Poulton Chapel	St. Owen's Church	Norton Priory
Male	169.8cm 5ft 7in (n=119)	169.3cm 5ft 7in (n=79)	172.4cm 5ft 8in (n=53)
Female	159.5cm 5ft 3in (n=121)	159.7cm, 5ft 3in (n=70)	157.4cm, 5ft 2in (n=9)

n=Number of Individuals

The demographics of the Poulton Chapel, St. Owen's Church and Norton Priory Collections presented here will form the foundation for the subsequent chapter. Chapter 5 tests the reliability of the recording methods for 30 NMTs reviewed in this thesis. The percentage frequency of all 126 NMTs for the Poulton Chapel, St. Owen's Church and Norton Priory Collections will be identified. Exploration of the effects of sex and age-at-death has on the frequency of all 126 NMTs and identify if there are any bi/unilateral differences between some NMTs. Further investigation will explore NMTs considered to be genetic in origin (n=75), ambiguous (n=29) and those likely associated with activity-related changes (n=22). The 22 NMTs traits associated with activity-related changes will be used to explore rural and urban divides between these populations and, if possible, by social segregation. The exploration of possible genetic relationships through hierarchal cluster analysis burial spatial organisation will be reviewed in Chapter 6

Chapter 5 Results Part 2

Nonmetric Trait Analysis

The purpose of this research is to determine the prevalence and variance of 126 NMTs found within and between the Medieval Poulton Chapel, St. Owen's Church and Norton Priory Collections. Majority of the objectives set for this thesis (see 1.7) will be met in this chapter. This chapter documents the frequency of 126 NMTs under the consideration of internal and external environmental factors (e.g. sexual dimorphism, age differences and bilateral symmetry) to explore the variation of these macroscopic observations. Further investigation will explore NMTs considered to be genetic in origin (n=75), ambiguous (n=29) and those likely associated with activity-related changes (n=22). The 22 NMTs traits associated with activity-related changes will be used to explore rural and urban divides between these populations and, if possible, by social segregation. The percentages reported here are the true prevalence of the data represented. Descriptions and illustrations of each NMT have been developed by the author and can be found in the Appendix with the associated scoring system identifying if the NMT is considered genetic, ambiguous or mechanical (see Appendix 1 and 2). Here, each skeleton has been reviewed individually and then collated to generate the results presented here. Overall, only 997 individuals were subjected to analysis (Poulton Chapel n=602; St. Owen's Church n=265; and Norton Priory n=130) as age-at-death and sex must be known for each individual to be included in the analysis. The exploration of possible genetic relationships through burial spatial organisation and hierarchal cluster analysis for each sample will be presented in Chapter 6.

5.1 Intra- and Inter-Observer Error

A compilation of 30 NMTs was randomly selected and subjected to intra/inter observer error using the Kappa Cohen's test for repeatability following the Landis and Koch's (1977) definitions (Table 19). This measure of agreement can range from 'Poor' to 'Almost Perfect', and traits that scored above 0.60 ('Moderate') were considered to be repeatable, and included in further analysis (Landis and Koch, 1977). A random sample was generated from the overall sample (n=867) from the Poulton Chapel and St. Owen's Church Collections to create a 10% subsample for re-evaluation (n=87). This random sample included 44 individuals from the Poulton Chapel Collection and 43 from the St. Owen's Church Collection. Due to restricted access to the Norton Priory Collection, these individuals were not included in the intra- and inter-observer analysis.

All 30 NMTs were tested for inter and intra-observer repeatability, and when applicable, traits were scored for both left and right sides. The list of traits subjected to inter- and intra-observer analysis are identified in Table 20. Although these NMTs were selected at random, the author believes they represent the variety of NMTs found within the human skeleton and of scoring types available. Descriptions and illustrations of all 126 NMTs were provided to the observers (see Appendix 1 and 2).

Table 19: Agreement measures for categorical data (Landis & Koch, 1977)

Kappa Statistic	Strength of Agreement
<0.00	Poor
0.00-0.20	Slight
0.21-0.40	Fair
0.41-0.60	Moderate
0.61-0.80	Substantial
0.81-1.00	Almost Perfect

5.1.1 Results of Intra-Observer Analysis

The intra-observer analysis was conducted four weeks after the initial data were collected. All 30 NMTs scored above 0.700 in regard to the Kappa Cohen's Value when testing for intra-observer error (Table 20). Using the Landis and Koch (1997) definitions of agreement (see Table 19), seven traits have 'Substantial' agreement between the intra-observer scores. The remaining NMTs (n=23) all scored above >0.80 identifying an 'Almost Perfect' level of agreement between intra-observer scores.

5.1.2 Results of Inter-Observer Analysis

The inter-observer analysis was conducted six to eight weeks after the initial data set was collected. Four observers were selected for this analysis. Each observer was provided with a copy of the descriptions and illustrations of the scoring methods presented in the Appendix (see Appendix 1 and 2) and no further assistance was provided. These observers are all experienced osteologists and PhD candidates in Biological Anthropology, each with their focused areas of research.

The first observer (OB1) holds the first-class BSc. (Hons) in Forensic Anthropology. OB1 has four years of experience of skeletal analysis of archaeological human skeletal remains, and their research area is focused on paleodemography, soil geochemistry and juvenile growth and development. The second observer (OB2) holds a first-class BSc. (Hons) in Forensic Anthropology with four years of experience of skeletal analysis on archaeological human skeletal remains but has researched the implications of stress and health on the human skeleton. The third observer (OB3) holds a first-class BSc.

(Hons) in Biological Anthropology and an MSc. in bioarchaeology with six years' experience of skeletal analysis on archaeological remains. Their research is focused on cranial and facial reconstruction, metric cranial analysis and paleopathology. The final observer (OB4) holds the first-class BSc. (Hons) in Forensic Anthropology with three years of experience of skeletal analysis on archaeological remains. The research of OB4 focuses on the patrituition and morphology of the human pelvis.

All traits showed a minimum level of 'Moderate' agreement between the scoring of all observers (see Table 21). For OB1, six traits scored between 0.4 and 0.6 (supraorbital foramen, parietal button osteoma, peroneal tubercle, extra lumbar vertebrae, accessory sacral facet and the third trochanter) identifying a 'Moderate' level of agreement between OB1 and the author. The occipital foramen and spondylolysis of the L5 neural arch both had a 'Substantial' level of agreement for both scorers. The remaining NMTs had an 'Almost Perfect' level of agreement. The second Observer (OB2), ten skeletal variants were scored at a 'Moderate' level of agreement (metopism, supraorbital foramen, parietal button osteoma, highest nuchal line, mandibular torus, carabelli's cusp, peg tooth, accessory sacral facet, vastus notch and the squatting facet). Five skeletal variants scored at the 'Substantial' level of agreement (lambdoid ossicle, occipital bun, suprascapular foramen, extra lumbar vertebrae and the third trochanter) while the remaining NMTs all scored above 0.81 NMTs scored between 0.6 and 0.8 (precondylar tubercle, humeral septal aperture, accessory sacral facet, acetabular crease and the third trochanter identifying a 'Substantial' level of agreement with the author. The remaining NMTs were scored at an 'Almost Perfect' level of agreement. Finally, for OB4, only the spondylolysis of the L5 neural arch scored a 'Moderate' level of agreement between with author. Six NMTs were scored at the 'Substantial' level of agreement (zygomatic facial foramen, lambdoid ossicle, occipital bun, suprascapular foramen, accessory sacral facet and the squatting facet), the remaining traits all scored above 0.8, an 'Almost Perfect' level of agreement with the author.

To conclude, all traits scored above 0.41 (a 'Moderate' level of agreement) and were included in the remaining analyses. It must be highlighted that the NMTs that were scored inconsistently to the author is due to the variability observed in the expression of a particular trait. For example, metopism is scored as present (1) when a complete suture line is present. However, for some individuals, an incomplete or residual metopic suture is evident and is to be scored differently (2). Unfortunately, this trait variation can be mistaken as absent (0) leading to inconsistencies in the recording.

Observers were asked to repeat their analysis two weeks after the original analysis and were asked to be conscious of individual NMT variation. With this, their level of agreement scores increased.

Table 20: Results of Intra-Observer analysis

Nonmetric Trait	Kappa Value	*p*-Value	Strength of Agreement
Metopism	1.000	<0.001	Almost Perfect
Supraorbital Foramen L	1.000	<0.001	Almost Perfect
Supraorbital Foramen R	1.000	<0.001	Almost Perfect
Zygomaticofacial Foramen L	1.000	<0.001	Almost Perfect
Zygomaticofacial Foramen R	0.879	-0.004	Substantial
Accessory Infraorbital Foramen L	0.875	-0.004	Substantial
Accessory Infraorbital Foramen R	0.875	-0.004	Substantial
Bregmatic Ossicle	1.000	<0.001	Almost Perfect
Parietal Button Osteoma L	1.000	<0.001	Almost Perfect
Parietal Button Osteoma R	1.000	<0.001	Almost Perfect
Sagittal Depression	1.000	<0.001	Almost Perfect
Highest Nuchal Line	1.000	<0.001	Almost Perfect
Ossicle at Lambda	0.787	0.003	Substantial
Lambdoid Ossicle L	1.000	<0.001	Almost Perfect
Lambdoid Ossicle R	0.719	-0.006	Substantial
Occipital Bun	1.000	<0.001	Almost Perfect
Occipital Foramen	1.000	<0.001	Almost Perfect
Precondylar Tubercle	0.773	-0.003	Substantial
Mandibular Torus L	1.000	<0.001	Almost Perfect
Mandibular Torus R	1.000	<0.001	Almost Perfect
Carabelli's Cusp L	1.000	<0.001	Almost Perfect
Carabelli's Cusp R	1.000	<0.001	Almost Perfect
Peg Tooth	1.000	<0.001	Almost Perfect
Suprascapular Foramen L	1.000	<0.001	Almost Perfect
Suprascapular Foramen R	1.000	<0.001	Almost Perfect
Sternal Aperture	1.000	<0.001	Almost Perfect
Humeral Septal Aperture L	1.000	<0.001	Almost Perfect
Humeral Septal Aperture R	1.000	<0.001	Almost Perfect
Occipitocervical Cranial Border Shift	1.000	<0.001	Almost Perfect
Bifurcation of C1 Neural Arch	1.000	<0.001	Almost Perfect
Block Fusion of C2 and C3	1.000	<0.001	Almost Perfect
Spondylolysis of L5 Neural Arch	1.000	<0.001	Almost Perfect
Extra Lumbar Vertebrae	1.000	<0.001	Almost Perfect
Accessory Sacral Facet L	0.738	-0.007	Substantial
Accessory Sacral Facet R	0.713	-0.010	Substantial
Acetabular Crease L	1.000	<0.001	Almost Perfect
Acetabular Crease R	0.700	-0.003	Substantial
Third Trochanter L	1.000	<0.001	Almost Perfect
Third Trochanter R	1.000	<0.001	Almost Perfect
Vastus Notch L	1.000	<0.001	Almost Perfect
Vastus Notch R	1.000	<0.001	Almost Perfect
Squatting Facet L	1.000	<0.001	Almost Perfect
Squatting Facet R	1.000	<0.001	Almost Perfect
Peroneal Tubercle L	1.000	<0.001	Almost Perfect
Peroneal Tubercle R	1.000	<0.001	Almost Perfect

Table 21: Results of Inter-Observer analysis

Nonmetric Trait	OB1 Kappa Value	OB2 Kappa Value	OB3 Kappa Value	OB4 Kappa Value
Metopism	1.000	0.446	1.000	1.000
Supraorbital Foramen L	1.000	0.446	1.000	1.000
Supraorbital Foramen R	0.422	0.446	1.000	1.000
Zygomaticofacial Foramen L	1.000	1.000	1.000	1.000
Zygomaticofacial Foramen R	1.000	1.000	1.000	0.639
Accessory Infraorbital Foramen L	1.000	1.000	1.000	1.000
Accessory Infraorbital Foramen R	1.000	1.000	1.000	1.000
Bregmatic Ossicle	1.000	1.000	1.000	1.000
Parietal Button Osteoma L	0.446	0.446	1.000	1.000
Parietal Button Osteoma R	1.000	1.000	1.000	1.000
Sagittal Depression	1.000	1.000	1.000	1.000
Highest Nuchal Line	1.000	0.544	1.000	1.000
Ossicle at Lambda	1.000	1.000	1.000	1.000
Lambdoid Ossicle L	0.789	0.726	1.000	0.606
Lambdoid Ossicle R	0.789	0.726	1.000	0.613
Occipital Bun	1.000	0.719	1.000	0.653
Occipital Foramen	0.789	1.000	1.000	1.000
Precondylar Tubercle	0.446	1.000	0.679	1.000
Mandibular Torus L	1.000	0.544	1.000	1.000
Mandibular Torus R	1.000	0.544	1.000	1.000
Carabelli's Cusp L	1.000	0.446	1.000	1.000
Carabelli's Cusp R	1.000	0.446	1.000	1.000
Peg Tooth	1.000	0.446	1.000	1.000
Suprascapular Foramen L	1.000	0.719	1.000	0.605
Suprascapular Foramen R	1.000	0.719	1.000	1.000
Sternal Aperture	1.000	1.000	1.000	1.000
Humeral Septal Aperture L	1.000	1.000	1.000	1.000
Humeral Septal Aperture R	1.000	1.000	0.789	1.000
Occipitocervical Cranial Border Shift	1.000	1.000	1.000	1.000
Bifurcation of C1 Neural Arch	1.000	1.000	1.000	1.000
Block Fusion of C2 and C3	1.000	1.000	1.000	1.000
Spondylolysis of L5 Neural Arch	0.679	1.000	1.000	0.446
Extra Lumbar Vertebrae	0.531	0.762	1.000	1.000
Accessory Sacral Facet L	0.446	0.544	0.679	0.639
Accessory Sacral Facet R	0.446	0.544	1.000	0.606
Acetabular Crease L	1.000	1.000	1.000	0.607
Acetabular Crease R	1.000	1.000	0.679	1.000
Third Trochanter L	0.443	0.745	0.747	1.000
Third Trochanter R	1.000	0.743	0.753	1.000
Vastus Notch L	1.000	0.446	1.000	1.000
Vastus Notch R	1.000	0.446	1.000	1.000
Squatting Facet L	1.000	0.544	1.000	1.000
Squatting Facet R	1.000	0.544	1.000	0.606
Peroneal Tubercle L	1.000	1.000	1.000	1.000
Peroneal Tubercle R	1.000	1.000	1.000	1.000

5.2 The Poulton Chapel Collection

After the skeletal analysis of the Poulton Chapel Collection (n=602), all 126 NMTs were collated into simple frequency tables (see Table 22 and 23). The data can be reviewed on a present/absent basis for all individuals. A preliminary review has identified that some NMTs appear more frequently than others.

Table 22: Frequency of the Cranial NMTs for the Poulton Chapel Collection

	Trait Score												
Nonmetric Trait	**1**	**0**	**9**	**1/1**	**1/0**	**0/1**	**1/9**	**9/1**	**0/9**	**9/0**	**0/0**	**9/9**
Metopism	176	260	166									
Supraorbital Foramen				41	40	47	1	0	4	2	301	166
Supraorbital Notch				150	42	56	3	2	2	0	181	166
Frontal Foramen				2	0	0	5	0	0	0	44	551
Zygomaticofacial Foramen				31	2	3	6	4	32	33	280	211
Accessory Infraorbital Foramen				35	1	0	2	4	22	16	320	202
Frontal Button Osteoma	6	432	164									
Frontal Bun	0	438	164									
Frontal Temporal Articulation				0	0	0	0	0	0	0	438	164
Bregmatic Ossicle	2	448	152									
Coronal Ossicle				0	1	1	0	0	3	7	454	136
Coronal Button Osteoma				0	1	0	0	0	3	7	455	136
Parietal Button Osteoma				0	3	1	0	0	4	8	457	129
Parietal Foramen				40	39	35	0	2	3	8	350	125
Auditory Torus				27	0	0	3	3	24	22	383	140
Mastoid Foramen				8	0	0	1	0	27	25	402	139
Sagittal Foramen	1	457	144									
Sagittal Ossicle	4	454	144									
Sagittal Bun	6	452	144									
Sagittal Depression	3	455	144									
Epipteric Ossicle				1	1	1	0	0	0	4	452	143
Parietal Notch Ossicle				7	3	1	1	0	0	4	443	143
Asterion Ossicle				6	4	6	0	0	0	4	439	143
Highest Nuchal line	0	465	137									
Ossicle at Lambda	26	440	136									
Lambdoid Ossicle				41	25	28	1	1	0	0	372	134
Occipital Bun	95	372	135									
Occipital Foramen	2	464	136									
Pars Basilaris Depression	1	420	181									
Precondylar Tubercle	2	419	181									
Occipital Osteoma	4	459	139									
Huschke Foramen				4	0	0	0	0	0	0	6	592
Posterior Condylar Canal				71	0	0	0	0	0	0	0	531
Occipital Condylar Facet				68	0	0	3	7	0	0	0	524

Skeletal variant scores: 1=Present, 0=Absent, 9=Unobservable. For bilateral traits, scores are given as left side/right side

Table 22 continued…

Nonmetric Trait	1	0	9	1/1	1/0	0/1	1/9	9/1	0/9	9/0	0/0	9/9
						Trait Score						
Anterior Condylar Canal				4	0	0	0	2	0	5	67	524
Foramen Ovale				0	0	0	0	0	0	0	71	531
Foramen Spinosum Open				0	0	1	0	0	0	0	70	531
Accessory Lesser Palatine Foramen				307	0	0	0	0	0	0	0	295
Palatine Torus	0	307	295									
Maxillary Torus				1	1	0	0	0	24	22	311	243
Mandibular Torus				3	0	1	0	0	2	4	445	147
Carabelli's Cusp Maxillary Deciduous 1st Molar				13	0	1	4	9	16	15	42	502
Carabelli's Cusp Mandibular Deciduos 1st Molar				83	5	1	10	8	5	3	10	477
Carabelli's Cusp Maxillary Permanent 1st Molar				24	1	0	2	9	32	24	109	401
Carabelli's Cusp Mandibular Permanent 1st Molar				136	3	2	22	12	9	14	44	360
Sixth Cusp Mandibular Permanent 2nd Molar				3	0	0	0	0	17	15	113	454
Maxillary Third Molar				112	3	4	22	25	4	4	17	411
Mandibular Third Molar				157	7	9	18	21	3	5	22	360
Peg Tooth	11	444	147									
Shovel Shaped Incisors	16	440	146									
Congenital Absence of Dentition	3	453	146									
Supernumerary Dentition	2	454	146									
Talan Cusp	2	453	147									
Late Eruption of Canines	1	455	146									
Enamel Pearls	0	456	146									

Skeletal variant scores: 1=Present, 0=Absent, 9=Unobservable. For bilateral traits, scores are given as left side/right side

Table 23: Frequency of the Postcranial NMTs for the Poulton Chapel Collection

	Trait Score											
Nonmetric Trait	**1**	**0**	**9**	**1/1**	**1/0**	**0/1**	**1/9**	**9/1**	**0/9**	**9/0**	**0/0**	**9/9**
Suprascapular Foramen				0	5	2	2	0	56	30	390	117
Acromial Articular Facet				0	0	0	0	0	59	31	396	116
Accessory Clavicle Facet				19	2	4	2	1	59	31	351	133
Sternal Aperture	1	142	459									
Humeral Supracondylar Process				1	3	1	0	0	60	39	384	114
Humeral Septal Aperture				13	10	7	4	1	56	39	357	115
Humeral Osteoma				0	0	0	0	0	60	40	387	115
Proximal Phalanx Osteoma				0	0	1	0	0	20	88	360	133
Single Atlas Articulating Facet				313	11	16	4	4	0	2	44	208
Double Atlas Articulating Facet				44	16	11	0	2	4	4	313	208
Occipitocervical Cranial Border Shift	1	393	208									
Bifurcation of C1 Neural Arch	2	392	208									
Clefting of C1 Neural Arch	4	390	208									
Bifurcation of C1 Anterior Neural Arch	1	390	211									
Block Fusion of C2 and C3	8	400	194									
Block Fusion of C3 and C4	0	408	194									
Block Fusion of C4 and C5	0	408	194									
Block Fusion of C5 and C6	0	414	188									
Block Fusion of C6 and C7	3	400	199									
Block Fusion of C7 and T1	0	403	199									
Cervicothoracic Cranial Border Shift	0	403	199									
Extra Thoracic Vertebrae	2	420	180									
Thirteenth Rib				2	0	0	0	0	0	0	438	162
Bifid Rib				0	0	0	0	0	0	0	440	162
Flared Rib				0	0	0	0	0	0	0	440	162
Congenital Absence of Thoracic Vertebrae	1	419	182									
Block Fusion of T7 and T8	2	418	182									
Block Fusion of T8 and T9	2	418	182									
Block Fusion of T9 and T10	2	418	182									
Block Fusion of T10 and T11	1	419	182									
Thoracolumbar Border Caudal Shift	2	419	181									
Lumbarisation of S1	2	416	184									
Sacralisation of L6	0	20	582									

Skeletal variant scores: 1=Present, 0=Absent, 9=Unobservable. For bilateral traits, scores are given as left side/right side

Table 23 continued…

Nonmetric Trait	Trait Score											
	1	0	9	1/1	1/0	0/1	1/9	9/1	0/9	9/0	0/0	9/9
Spondylolysis of L6 Arch	1	19	582									
Bifurcation of L6 Neural Arch	0	20	582									
Clefting of L6 Neural Arch	0	20	582									
Accessory Lumbar Facet	4	406	192									
Bifurcation of S1 Neural Arch	9	414	179									
Clefting of S1 Neural Arch	7	416	179									
Bifurcation of S2 Neural Arch	0	423	179									
Clefting of S2 Neural Arch	5	396	201									
Spina Bifida Occulta	32	392	178									
Accessory Sacral Facet				31	4	7	1	2	33	26	380	118
Ilium Foramen				75	2	0	1	8	33	21	346	116
Sacroiliac Joint Fusion				1	2	0	0	0	33	29	419	118
Acetabular Crease				1	0	0	0	0	30	18	412	141
Femoral Osteoma				0	3	0	0	0	21	19	440	119
Femoral Supracondylar Process				0	1	0	0	0	21	18	443	119
Femoral Anteversion				3	6	2	0	0	22	20	431	118
Allen's Fossa				14	0	3	0	2	23	20	417	123
Poirier's Facet				3	0	1	0	0	23	22	430	123
Plaque Formation				22	4	5	0	0	23	22	403	123
Hypertrochanteric Fossa				82	10	12	5	2	18	19	335	119
Third Trochanter				91	15	7	1	5	21	15	327	120
Vastus Notch				28	0	4	3	3	22	16	288	238
Tibia Anteversion				3	0	0	0	0	16	12	440	131
Tibia Osteoma				0	1	0	0	0	16	12	442	131
Squatting Facet				166	4	5	4	3	11	8	253	148
Inferior Talus Single Articular Facet				239	3	7	16	19	4	1	112	201
Inferior Talus Double Articular Facet				112	7	3	4	1	16	19	239	201
Single Calcaneal Articular Facet				241	5	11	16	22	3	0	115	189
Double Calcaneal Articular Facet				115	11	5	3	0	16	22	241	189
Peroneal Tubercle				70	4	7	2	1	16	15	300	187
Metatarsal Osteoma				0	0	0	0	0	18	16	381	187

Skeletal variant scores: 1=Present, 0=Absent, 9=Unobservable. For bilateral traits, scores are given as left side/right side

Occasionally, multiple occurrences of a single NMT were recorded for individual skeletons. For this sample, six skeletal variants presented multiple occurrences of a single trait (supraorbital foramen, zygomatic facial foramen, frontal osteoma, parietal osteoma, ossicle at lambda and the lambdoid ossicle). However, this is not uncommon and has been reported to occur in other collections. Alongside this, a further variation of certain NMTs was also apparent. For example, the variation of an incomplete metopic suture can vary by size and by shape (Burrell *et al.,* 2017). Further exploration of the variability of individual NMTs, such as metopism is being considered for future research (see 7.4).

Alongside this, it was noted that some individuals have a higher prevalence of numerous NMTs than others. Here, the frequency rates of the total number of NMTs expressed in a single individual are shown in Figure 26. Figure 26 shows the variance of expression between the non-adult and adult individuals. Interestingly, there is a high number of non-adults exhibiting fewer skeletal variants, demonstrating that the expression of skeletal variants is likely reflected with increasing age. So, as the skeleton of a non-adult develops, the morphology of the skeletal element changes affecting the skeletal variants observed. The total number of skeletal variants expressed between the males and females are similar. However, the preservation and completeness of these individuals must be considered. Even though the sample size for the Poulton Chapel Collection is remarkably large (n=602) the preservation and completeness of each individual vary considerably (Chapter 4.1). The overall completeness of these individuals is a continuous issue with the Poulton Chapel Collection as the burial ground has been heavily used over the centuries. This, in turn, has led to a high occurrence of truncated burials across the site (Burrell and Carpenter, 2013).

The simultaneous occurrence of several different NMTs (intertrait associations) is to be expected between certain traits. As reviewed in 1.5, researchers often review NMTs on an individual basis although this does not mean that they are necessarily independent. During the analysis of this sample, there are multiple occurrences of supernumerary sutural bones (i.e. lambdoid ossicle) and, in some instances, these are recorded as present alongside the occurrence of metopism and/or with the ossicle at lambda. This process has various factors, and a review of these intertrait associations are being considered for future research (see 7.4).

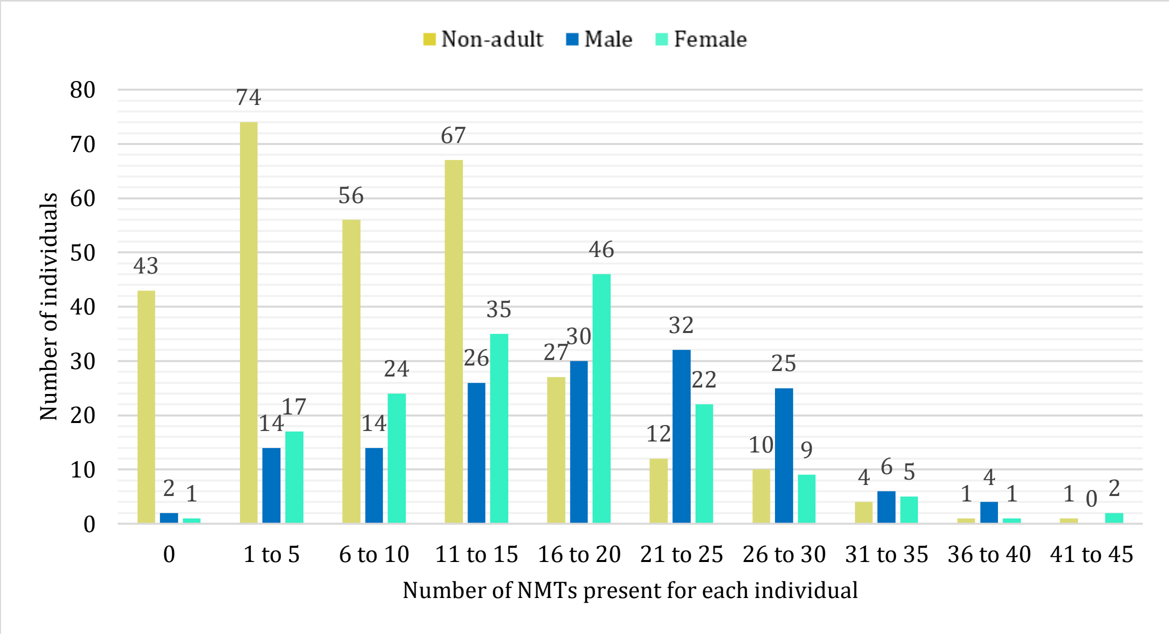

Figure 26: Frequency of NMTs for the Poulton Chapel Collection

5.2.1 Percentage Differences

Preliminary percentage overviews were made between the non-adult (n=295) and adult (n=307) sample, with the adult sample further defined by sex (males: n=145, females: n=162). Further details can be found in the Appendix (see Appendix 5). There are some differences between the percentage rates observed for certain NMTs within the adult sample. The majority of NMTs were evenly spread amongst the male and female sample. However, a few traits showed notable percentage differences between the sexes with some traits only occurring for a single sex. Here, 19 NMTs were only reported as present for the male sample while 17 other NMTs were reported within the female sample (see Table 24). However, the frequency of occurrence of these traits is small (e.g. sagittal foramen, n=1) in comparison to other NMTs (e.g. metopism, n=176). Such instances do not provide a suitable sample for comparison between the sexes.

Table 24: Occurrence of NMTs within a single sex for the Poulton Chapel Collection

	Males		Females	
Nonmetric Trait	**n**	**%**	**n**	**%**
Sagittal Foramen	1	100	0	-
Sagittal Ossicle	1	100	0	-
Supernumerary Dentition	1	100	0	-
Late Eruption of Canines	1	100	0	-
Sternal Aperture	1	100	0	-
Occipitocervical Cranial Border Shift	1	100	0	-
Bifurcation of C1 Neural Arch	2	100	0	-
Block Fusion of C6 and C7	3	100	0	-
Extra Thoracic Vertebrae	2	100	0	-
Block Fusion of T7 and T8	2	100	0	-
Block Fusion of T9 and T10	2	100	0	-
Lumbarisation of L6	1	100	0	-
Spondylolysis of L6 Neural Arch	1	100	0	-
Accessory Lumbar Facet	1	100	0	-
Bifurcation of S1 Neural Arch	3	100	0	-
Coronal Ossicle	2	100	0	-
Sixth Cusp Mandibular Permanent 2nd Molar	1	100	0	-
Thirteenth Rib	2	100	0	-
Bregmatic Ossicle	0	-	2	100
Sagittal Depression	0	-	3	100
Occipital Foramen	0	-	2	100
Precondylar Tubercle	0	-	1	100
Occipital Osteoma	0	-	3	100
Talan Cusp	0	-	1	100
Congenital Absence of Thoracic Vertebrae	0	-	1	100
Block Fusion of T10 and T11	0	-	1	100
Lumbarisation of S1	0	-	1	100
Block Fusion of L1 and L2	0	-	1	100
Spondylolysis of L4 Neural Arch	0	-	1	100
Bifurcation of L5 Neural Arch	0	-	1	100
Coronal Osteoma	0	-	1	100
Foramen Spinosum Open	0	-	1	100
Proximal Phalanx Osteoma	0	-	1	100
Femoral Supracondylar Process	0	-	1	100
Tibia Osteoma	0	-	1	100

n=Number of individuals

Seventeen NMTs presented large percentage differences between the sexes (Table 25). To select a few, the sagittal bun was recorded six times during skeletal analysis, five of whom were males (88.3%). A peg tooth was recorded on ten occasions and present in 70% of females (n=7). An extra lumbar vertebra was recorded 20 times for the Poulton Chapel sample, with eight observed in the male sample (66.7%) and four for the female sample (33.3%) with the remaining eight recorded within the non-adult sample. Block fusion of C2 and C3 was predominantly favoured for the male sample (87.5%) while the humeral septal aperture was generously recorded 26 times with a higher percentage for the female sample (76.9%). Although the Poirier's facet and the mandibular torus was low for the total sample, these NMTs were more common in males (75%) than females (25%) while the opposite was found for the parietal osteoma with 75% of females exhibiting this trait.

Table 25: Noticeable Percentage Differences for the Poulton Chapel Collection

Nonmetric Trait	N	Males		Females	
		n	%	n	%
Sagittal Bun	6	5	83.3	1	16.7
Peg Tooth	10	3	30	7	70
Block Fusion of C2 and C3	8	7	87.5	1	12.5
Spondylolysis of L5 Neural Arch	7	2	28.5	5	71.5
Extra Lumbar Vertebrae	12	8	66.7	4	33.3
Clefting of S1 Neural Arch	6	4	66.7	2	33.3
Frontal Foramen	3	1	33.3	2	66.7
Parietal Osteoma	4	1	25	3	75
Asterion Ossicle	12	8	66.7	4	33.3
Mandibular Torus	4	3	75	1	25
Suprascapular Foramen	9	2	22.2	7	77.8
Humeral Septal Aperture	26	6	23.1	20	76.9
Femoral Osteoma	3	2	66.7	1	33.3
Femoral Anteversion	10	3	30	7	70
Third Trochanter	84	34	40.5	50	59.5
Poirier's Facet	4	3	75	1	25
Vastus Notch	35	19	54.2	16	45.7

N=Total number of NMTs recorded, n=Number of individuals

The adult sample was further split into three broad age-at-death categories (18 to 24.99 (n=39), 25 to 44.99 (n=160) and 45+ (n=108) years of age). The percentage differences were evenly spread for all NMTs between the 25 to 44.99 and 45+ age-at-death category. However, the youngest category (18 to 24.99 years) exhibited differences for numerous NMTs. For example, metopism was present in only 13% of adults in the youngest age-at-death category, while 51% were between 24 to 44.99 years of age and 36% of adults fell within the oldest category. This may appear interesting however, the sample size for the youngest age-at-death category is much lower in comparison to the sample size of the other two categories. This difference probably explains the discrepancy identified here and with other NMTs. Nonetheless, an individual who exhibits a trait in early adulthood (18 to 24.99 years of age) are likely to retain the trait until later life. Separately, the non-adult sample was reviewed further by their broad age-at-death categories (0 to 4.99 (n=141), 5 to 11.99 (n=120), and 12 to 17.99 (n=34) years of age). The percentage differences were similar for almost all NMTs between 5 and 17.99 years of age. However, the youngest category (0 to 4.99 years of age) exhibited much lower percentages for the majority of NMTs recorded. For example, the humeral septal aperture was recorded on 12 occasions for non-adults between 5 to 17.99 years of age while none were reported for those under the age of 5 years. Interestingly, supernumerary sutural variants (e.g. sagittal ossicle and ossicle at lambda) were reported for all age categories supporting the previous statement made by El-Najjar and Dawson (1977) who reported the presence of sutural variants in foetal crania. It must be clarified that some NMTs cannot be recorded for individuals within the youngest age-at-death category. Most of the variants highlighted are those for which expression is still under development. For example, the third molar does not begin to erupt until approximately 16 years of age (AlQahtani *et al.,* 2010). However, the germ appearance of this tooth can be observed in the crypt around eight years of age if a radiographic image is available (AlQahtani *et al.,* 2010). Similar to this is the appearance of the vastus notch as primary ossification of the patella does not occur until around 8 years of age (Schaefer *et al*., 2009). However, the sample size of the material present should also be considered for this variability. Overall, these results suggest that there is an age progressive nature to some NMTs, with the full expression not occurring until later life (e.g. humeral septal aperture) but others are present throughout ontogeny (e.g. supernumerary sutural bones) supporting previous statements (Buikstra, 1972; Berry, 1975; and Perizonous, 1979).

5.2.2 Bilateral Differences

Bilateral differences were also explored for this collection. A Chi-square test for independence compares two variables in a contingency table to see if they are related to one another. Such analyses are applied to identify if there is dominance for a certain side (left or right) for each NMT, specifically those considered to be activity-related. For the Poulton Chapel sample, there was little or no difference in the percentage frequencies between left and right sides (see Table 22 and 23). Because of this, statistical analysis was not applied to NMTs with no percentage differences. However, NMTs that presented slight percentage differences (e.g. the supraorbital notch and femoral anteversion) were subjected to this analysis. This analysis was applied to the entire Poulton Chapel sample were '1' or '0' was scored. These tests were repeated to consider differences between the adult and non-adult samples, between the sexes and, between age-at-death categories for the Poulton Chapel sample. Here, all results presented large p values over 0.05 suggesting that there are no bilateral differences for any NMTs within the Poulton Chapel sample.

5.2.3 Sex Differences

The comparison of sex was only applied to the Poulton Chapel adults (n=307). These analyses will determine whether there are any statistical differences between the sexes that are significant. The percentage frequency of each NMT for the males (n=145) and the females (n=162) can be found in Appendix 5. For traits that were scored for both left and right sides, the highest score was used since this value represents that maximum expression of a specific NMT. A Mann-Whitney U test was applied to the categorical (present '1' and absent '0') data to explore any differences between the sexes for each NMT (n=126). Overall, most NMTS presented no differences between the sexes. However, seven NMTs did present a significant difference between the sexes. The humeral septal aperture (U=6990.00, Z=-2.682, p=0.007), inferior talus single articular facet (U=5901.50, Z=-1.961, p=0.050) and the single calcaneus articular facet (U=5929.00, Z=-2.562, p=0.010) were found more in the female sample. Whilst block fusion of the C2 and C3 (U=6080.00, Z=-2.245, p=0.025), the inferior talus double articular facet (U=5901.50, Z=-1.961, p=0.050), the double calcaneus articular facet (U=5929.00, Z=-2.562, p=0.010) and finally, the peroneal tubercle (U=6100.00, Z=-2.533, p=0.011) were found more in the male sample. It must be noted that these results are significant due to the set level of $p<0.05$ for significance. However, if the Bonferroni adjusted value is applied to these results (p=0.00039683), there are no statically significant differences observed between the sexes for any NMT.

5.2.4 Age-at-death Differences

The effects of age-at-death on the occurrence of 126 NMTs were explored for this sample. For ease of analysis, the non-adults and adults were grouped into broad age categories (For non-adults: 0 to 4.99 (n=141), 5 to 11.99 (n=120) and 12 to 17.99 (n=34) years of age. For adults: 18 to 24.99 (n=39), 25 to 44.99 (n=160) and 45+ (n=108) years of age). The percentage data for each NMT will be tested against each age-at-death category to determine if there are any differences between the groups. For traits that were scored for both left and right sides, the highest score was used since this value represents that maximum expression of a specific NMT. The Kruskal-Wallis H Test was applied to the categorical (present '1' and absent '0') data to explore any differences between the age-at-death categories for each NMT (n=126). Almost all NMTs showed a significant difference between the six age-at-death categories for the Poulton Chapel sample (results ranging: $\chi^2(5)$= 1.217 to 178.396, p=<0.001 to 0.047; data not shown). As previously mentioned in 3.7, this test statistic cannot identify which groups differed to each other. Because of this, a one-way ANOVA and the Tukey's HSD post-hoc test was applied to the data (Zarr, 2010). Like the Kruskal-Wallis H Test, the one-way ANOVA test found a statistical difference between the six groups (F=49.703; p=<0.001). The Tukey's HSD test identified significant differences between some of the age-at-death categories specifically between the 0 to 4.99 category and adults above 25 years of age (p=<0.001). There is a difference between the 0 to 4.99 and 5 to 11.99 categories (p=0.027) although none or little difference were found for the remaining groups (p=0.997 to p=1). These tests were repeated using separate NMT categories (genetic, activity-related and ambiguous). All tests produced statistically significant results; genetic NMTs (F=16.142; p=<0.001), activity-related NMTs (F=71.017; p=<0.001) and finally, ambiguous NMTs (F=16.347; p=<0.001). A Tukey's HSD test was applied to age NMT category, and similar results were seen between each NMT category. Little or no differences were found between the three non-adult age-at-death categories (p=0.989 to p=1). However, significant differences were reported between the non-adult and adult age-at-death categories (p=<0.001 to p=0.031). These results are unsurprising as non-adults exhibit fewer or less NMTs in comparisons to the adult sample. This is primarily due to the continuous ontogenic development (Buikstra, 1972; Korey, 1980; and Hauser and De Stefano, 1989).

These tests were repeated just for the non-adult sample (0 to 4.99, 5 to 11.99 and 12 to 17.99 age-at-death categories). The Kruskal-Wallis H Test revealed a significant statistical difference for 57 NMTs (results ranging: $\chi^2(2)$=6.493 to 37.662, p=<0.001 to 0.05; data not shown) between the three age-at-death categories. As shown above, these data were re-run using the one-way ANOVA and the Tukey's HSD post-hoc test statistic to identify which groups showed significant differences to each other. Like the Kruskal-Wallis H Test, the one-way ANOVA test found significant differences between the three groups (F=9.191; p=<0.001). The Tukey's HSD test identified further significant differences between the 0 to 4.99 and 5 to 11.99 age-at-death categories (p=<0.001), and between the 5 to 11.99 and 12 to 17.99 age-at-death categories (p=0.002). However, little difference was found between the 0 to 4.99 and 12 to 17.99 age-at-death category (p=0.810). For consistency, these tests were repeated for the different NMT categories (genetic, activity-related and ambiguous). Significant differences were found for the genetic (F=7.738; p=<0.001) and the activity-related (F=4.706; p=0.011) NMTs. The Tukey's HSD test identified that the differences occurred between the 0 to 4.99 and 5 to 11.99 age-at-death categories (p=0.001 to p=0.44) and between the 5 to 11.99 and 12 to 17.99 age-at-death categories (p=0.005 to p=0.014). Little difference was found between the 0 to 4.99 and 12 to 17.99 age-at-death category (p=0.907 to p=0.911). However, when only the ambiguous traits were used, no significance was found between the three age-at-death categories (F=0.480; p=0.620).

These tests were repeated just for the adult sample (18 to 24.99 (n=39), 25 to 44.99 (n=160) and 45+ (n=108) age-at-death categories). The Kruskal-Wallis H Test revealed a significant statistical difference for nine NMTs between the three age-at-death categories (see Table 26). Although these skeletal variants have been highlighted with significant age-at-death differences, additional testing was not sought to identify which age-at-death categories presented significant statistical differences between the groups. This is due to previous statements made by Berry (1975), Perizonius (1979) and Hauser and De Stefano (1989) who all mention that all NMTs should be fully expressed by adulthood, excluding pre-puberty material, suggesting that any differences seen between the age categories above 25 years of age can be discounted.

Table 26: Results of the Kruskal-Wallis H Test for the adult Poulton Chapel sample

Nonmetric Trait	Kruskal-Wallis H Results (χ^2)
Accessory Lesser Palatine Formation	$\chi^2(5) = 14.557$, p =0.001
Palatine Torus	$\chi^2(5) = 14.557$, p =0.001
Maxillary Torus	$\chi^2(5) = 7.869$, p =0.020
Carabelli's Cusp Maxillary Permanent 1st Molar	$\chi^2(5) = 44.947$, p =<0.001
Carabelli's Cusp Mandibular Permanent 1st Molar	$\chi^2(5) = 42.461$, p =<0.001
Sixth Cusp Mandibular Permanent 2nd Molar	$\chi^2(5) = 29.416$, p =<0.001
Maxillary Third Molar	$\chi^2(5) = 13.327$, p =<0.001
Mandibular Third Molar	$\chi^2(5) = 13.625$, p =0.001
Sternal Aperture	$\chi^2(5) = 16.082$, p =<0.001

5.3 The St. Owen's Church Collection

After the skeletal analysis of the St Owen's Church Collection (n=265), all 126 NMTs were collated into simple frequency tables (see Table 27 and 28). The data can be reviewed on a present/absent basis for all individuals and a preliminary review has identified that some NMTs appear more frequently than others. As previously noted for the Poulton Chapel Collection, multiple occurrences of a single NMT can occur within an individual. For the St. Owen's Church Collection, four skeletal variants presented multiple occurrences of a single trait (supraorbital foramen, zygomatic facial foramen, ossicle at lambda and the lambdoid ossicle). The same traits presented multiple occurrences within the Poulton Chapel Collection, and other collections report such instances. Relatedly, further variation of a single trait has been reported. In 5.2, the variation of metopism was provided as an example due to the numerous variation types observed (Ajmani e*t al.,* 1983). However, another example can include a variation of a supernumerary sutural bone, e.g. a bregmatic ossicle which can vary in shape and size (Barberini *et al.,* 2008). Such variances of NMTs reported in this collection are being considered for future analyses (see 7.4).

Table 27: Frequency of the Cranial NMTs for the St. Owen's Church Collection

	Trait Score											
Nonmetric Trait	**1**	**0**	**9**	**1/1**	**1/0**	**0/1**	**1/9**	**9/1**	**0/9**	**9/0**	**0/0**	**9/9**
Metopism	60	55	150									
Supraorbital Foramen				31	9	11	2	3	7	3	47	152
Supraorbital Notch				50	13	8	4	4	5	2	27	152
Frontal Foramen				19	1	0	2	3	9	13	79	139
Zygomaticofacial Foramen				46	3	2	9	22	6	4	18	155
Accessory Infraorbital Foramen				37	0	1	7	4	6	4	42	164
Frontal Button Osteoma	8	109	148									
Frontal Bun	0	162	104									
Frontal Temporal Articulation				0	0	0	0	0	10	7	99	149
Bregmatic Ossicle	0	113	153									
Coronal Ossicle				0	1	0	0	0	0	2	109	153
Coronal Button Osteoma				0	1	0	0	0	0	2	109	153
Parietal Button Osteoma				0	2	0	0	0	2	5	118	138
Parietal Foramen				21	13	11	1	0	2	5	75	137
Auditory Torus				74	0	0	9	5	8	2	47	120
Mastoid Foramen				38	1	2	0	1	17	6	77	123
Sagittal Foramen	2	135	128									
Sagittal Ossicle	5	132	128									
Sagittal Bun	2	135	128									
Sagittal Depression	3	134	128									
Epipteric Ossicle				0	1	0	0	0	2	2	131	129
Parietal Notch Ossicle				2	0	0	2	0	1	2	131	127
Asterion Ossicle				3	3	0	0	0	2	2	129	126
Highest Nuchal line	1	138	126									
Ossicle at Lambda	17	129	119									
Lambdoid Ossicle				16	4	12	0	1	0	1	113	118
Occipital Bun	58	67	140									
Occipital Foramen	12	112	141									
Pars Basilaris Depression	7	85	173									
Precondylar Tubercle	0	57	209									
Occipital Osteoma	3	117	145									
Huschke Foramen				15	0	0	0	0	0	0	14	236
Posterior Condylar Canal				0	0	0	2	1	33	0	27	202
Occipital Condylar Facet				38	0	0	49	40	0	0	0	138

Skeletal variant scores: 1=Present, 0=Absent, 9=Unobservable. For bilateral traits, scores are given as left side/right side

Table 27: Continued…

Nonmetric Trait	1	0	9	1/1	1/0	0/1	1/9	9/1	0/9	9/0	0/0	9/9
						Trait Score						
Anterior Condylar Canal				0	1	0	1	1	2	49	16	195
Foramen Ovale				0	0	6	0	4	3	1	13	238
Foramen Spinosum Open				0	2	2	3	1	7	4	8	238
Accessory Lesser Palatine Foramen				0	0	8	2	10	0	0	123	122
Palatine Torus				0	1	0	0	1	4	15	87	157
Maxillary Torus				0	0	2	1	0	17	8	84	153
Mandibular Torus				2	1	0	1	0	5	5	107	144
Carabelli's Cusp Maxillary Deciduous 1st Molar				4	0	0	2	2	0	3	8	246
Carabelli's Cusp Mandibular Deciduos 1st Molar				20	1	0	1	4	1	0	1	237
Carabelli's Cusp Maxillary Permanent 1st Molar				5	1	0	3	0	4	7	29	216
Carabelli's Cusp Mandibular Permanent 1st Molar				28	0	1	3	7	4	4	20	198
Sixth Cusp Mandibular Permanent 2nd Molar				1	0	0	0	0	7	8	32	217
Maxillary Third Molar				40	0	3	4	10	1	2	7	198
Mandibular Third Molar				60	1	1	3	1	1	3	7	188
Peg Tooth	3	115	147									
Shovel Shaped Incisors	1	116	148									
Congenital Absence of Dentition	1	116	148									
Supernumerary Dentition	1	116	148									
Talan Cusp	0	118	148									
Late Eruption of Canines	1	116	148									
Enamel Pearls	1	120	144									

Skeletal variant scores: 1=Present, 0=Absent, 9=Unobservable. For bilateral traits, scores are given as left side/right side

Table 28: Frequency of the Postcranial NMTs for the St. Owen's Church Collection

	Trait Score											
Nonmetric Trait	**1**	**0**	**9**	**1/1**	**1/0**	**0/1**	**1/9**	**9/1**	**0/9**	**9/0**	**0/0**	**9/9**
Suprascapular Foramen				3	0	1	0	0	27	29	109	96
Acromial Articular Facet				0	0	0	0	0	26	27	110	102
Accessory Clavicle Facet				13	7	5	4	5	28	23	69	111
Sternal Aperture	1	74	190									
Humeral Supracondylar Process				0	4	3	2	2	37	31	87	99
Humeral Septal Aperture				4	3	2	2	1	38	33	83	99
Humeral Osteoma				0	2	0	0	0	56	63	82	62
Proximal Phalanx Osteoma				0	0	0	0	0	70	38	93	64
Single Atlas Articulating Facet				81	0	0	15	3	0	0	0	166
Double Atlas Articulating Facet				81	0	0	15	3	0	0	0	166
Occipitocervical Cranial Border Shift	0	106	160									
Bifurcation of C1 Neural Arch	0	99	167									
Clefting of C1 Neural Arch	0	99	167									
Bifurcation of C1 Anterior Neural Arch	0	99	167									
Block Fusion of C2 and C3	0	121	145									
Block Fusion of C3 and C4	0	146	120									
Block Fusion of C4 and C5	0	91	175									
Block Fusion of C5 and C6	1	121	143									
Block Fusion of C6 and C7	0	124	142									
Block Fusion of C7 and T1	0	124	142									
Cervicothoracic Cranial Border Shift	1	124	140									
Extra Thoracic Vertebrae	1	129	135									
Thirteenth Rib				1	0	0	0	0	0	0	37	227
Bifid Rib				2	0	0	0	0	0	0	40	223
Flared Rib				0	1	3	0	0	150	2	39	70
Congenital Absence of Thoracic Vertebrae	0	144	122									
Block Fusion of T7 and T8	1	149	115									
Block Fusion of T8 and T9	1	149	115									
Block Fusion of T9 and T10	1	149	115									
Block Fusion of T10 and T11	0	152	114									
Thoracolumbar Border Caudal Shift	1	142	122									
Lumbarisation of S1	9	133	124									
Sacralisation of L6	1	234	30									

Skeletal variant scores: 1=Present, 0=Absent, 9=Unobservable. For bilateral traits, scores are given as left side/right side

Table 28 Continued…

Nonmetric Trait	1	0	9	1/1	1/0	0/1	1/9	9/1	0/9	9/0	0/0	9/9
						Trait Score						
Spondylolysis of L6 Arch	0	5	261									
Bifurcation of L6 Neural Arch	0	5	261									
Clefting of L6 Neural Arch	2	38	225									
Accessory Lumbar Facet	0	135	131									
Bifurcation of S1 Neural Arch	15	118	132									
Clefting of S1 Neural Arch	3	130	132									
Bifurcation of S2 Neural Arch	2	124	139									
Clefting of S2 Neural Arch	2	124	139									
Spina Bifida Occulta	36	95	134									
Accessory Sacral Facet				36	4	6	7	5	25	18	102	62
Ilium Foramen				142	3	0	32	21	2	4	3	58
Sacroiliac Joint Fusion				1	2	2	1	0	33	24	143	59
Acetabular Crease				2	1	2	0	1	32	21	144	62
Femoral Osteoma				0	3	2	0	0	30	17	151	62
Femoral Supracondylar Process				0	1	2	0	0	27	19	151	65
Femoral Anteversion				0	0	0	0	0	30	19	154	62
Allen's Fossa				6	0	2	1	1	32	24	132	67
Poirier's Facet				5	1	1	1	0	32	25	133	67
Plaque Formation				11	2	2	4	0	28	25	126	67
Hypertrochanteric Fossa				61	6	7	13	10	19	15	70	64
Third Trochanter				28	8	7	8	7	25	18	100	64
Vastus Notch				7	0	2	3	0	18	12	60	163
Tibia Anteversion				0	0	1	0	0	15	18	137	94
Tibia Osteoma				0	1	0	0	0	16	18	137	93
Squatting Facet				30	1	6	3	6	9	8	59	143
Inferior Talus Single Articular Facet				67	0	0	12	15	0	0	0	171
Inferior Talus Double Articular Facet				67	0	0	12	15	0	0	0	171
Single Calcaneal Articular Facet				75	1	0	14	13	0	0	0	162
Double Calcaneal Articular Facet				75	1	0	14	13	0	0	0	162
Peroneal Tubercle				35	3	2	5	6	8	8	38	160
Metatarsal Osteoma				1	0	0	0	0	4	8	178	74

Skeletal variant scores: 1=Present, 0=Absent, 9=Unobservable. For bilateral traits, scores are given as left side/right side

The frequency of each trait has been reported for this sample (see Appendix 6). However, during the skeletal analysis is was noted that some individuals express numerous NMTs while others other express a few selected NMTs. Here, the frequency of the total number of NMTs expressed in a single individual are shown in Figure 27. Figure 27 shows the variation of the number of traits expressed between the non-adult and adult sample. As previously observed in the Poulton Chapel Collection, there is a high number of non-adults who exhibit fewer traits in comparison to their adult counterparts. This supports the probability that the expression of skeletal variants is reliant on the development and changing morphology of the non-adult skeleton (Buikstra, 1972; Korey, 1980; Hauser and De Stefano, 1989; and Kitagawa, 1995). Suggesting that the expression of some MNTs do not become apparent until later life when the skeleton has completed growth.

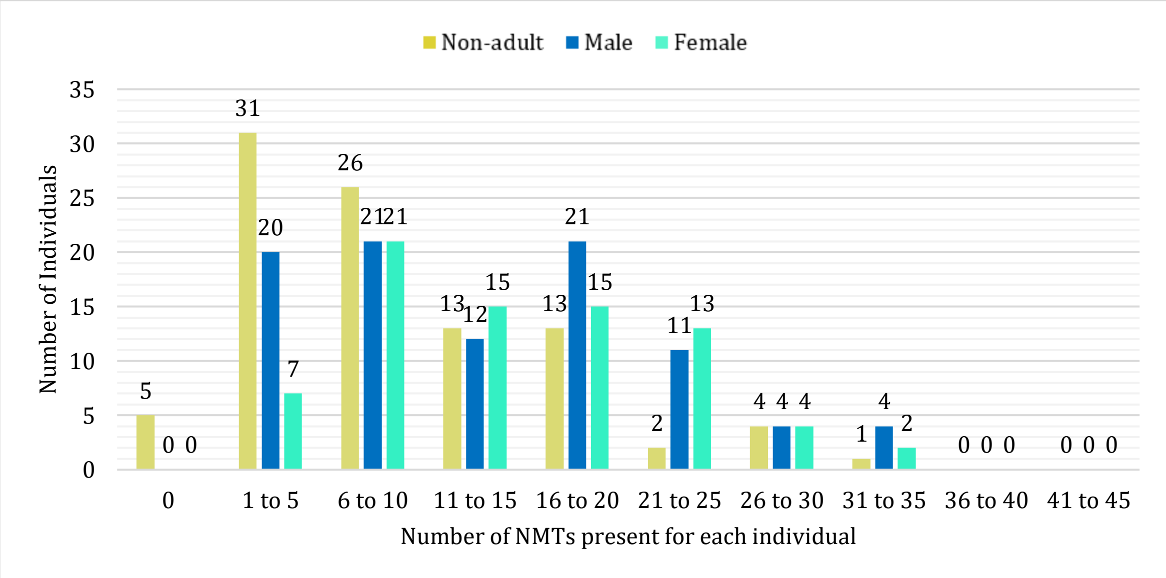

Figure 27: Frequency of NMTs for the St. Owen's Church Collection

On the other hand, the number of traits observed between the male and female sample is quite similar although no individuals from this sample exhibit more than 36 NMTs at any one time. Interestingly, there is a distinct peak of adults showing fewer traits; this is likely due to the preservation of the skeletons at St. Owen's Church. As previously discussed for the Poulton Chapel Collection, the preservation and completeness of these individuals must be considered during interpretation. The sample size for the St. Owen's Church Collection is reasonable (n=265) but the preservation of this collection is not to a high standard. The skeletal elements and bone surfaces are frailer than that seen at Poulton, affecting the recording of numerous NMTs. Alongside this, some burials are truncated by later burials affecting the completeness of numerous individuals within this collection. As mentioned earlier, there is an occurrence of intertrait associations between some NMTs, some of which are to be expected (e.g. metopism and the ossicle at lambda). This thesis reviews each trait independently; however, a review of various intertrait associations are being considered for future research (see Chapter 7.4).

5.3.1 Percentage Differences

Preliminary percentage overviews were made between the non-adult (n=95) and adult (n=170) sample, with the adult sample further defined by sex (males: n=93, females: n=77). Further details can be found in the Appendix (see Appendix 6). The majority of NMTs were evenly spread amongst the male and female sample. However, several NMTs showed notable percentage differences between the sexes with some traits only occurring for a single sex. Here, 27 NMTs were only reported as present for the male sample while 13 different NMTs were only reported for the female sample (see Table 29). However, the overall frequency of occurrence for these NMTs is no higher than five. Although such differences observed between the sexes and these NMTs, one must be careful with the interpretation of such small sample sizes.

Nineteen NMTs presented notable percentage differences between the sexes (see Table 30). Although some of these NMTs only occur in small frequency for the entire sample (inclusive of non-adults), some traits are of interest. The occipital bun is recorded 37 times for which 24 were females (64.9%) and only 13 were male (35.1%). The frontal foramen was recorded 25 times and was more frequent in males (73.7%) than the females (26.3%). The sagittal depression, parietal ossicle and the flared rib were more common in males (66.7%) than the females. The humeral supracondylar process was more favoured towards the male sample at a percentage of 80%.

Table 29: Occurrence of NMTs within a single sex for the St. Owen's Church Collection

	Males		Females	
Nonmetric Trait	**n**	**%**	**n**	**%**
Sagittal Foramen	2	100	0	-
Sagittal Bun	1	100	0	-
Occipital Osteoma	3	100	0	-
Peg Tooth	1	100	0	-
Shovel Shaped Incisors	1	100	0	-
Sternal Aperture	1	100	0	-
Block Fusion of C5 and C6	1	100	0	-
Block Fusion of T7 and T8	1	100	0	-
Block Fusion of T8 and T9	1	100	0	-
Block Fusion of T9 and T10	1	100	0	-
Spondylolysis of L5 Neural Arch	1	100	0	-
Bifurcation of L5 Neural Arch	2	100	0	-
Extra Lumbar Vertebra	1	100	0	-
Clefting of L6 Neural Arch	1	100	0	-
Clefting of S1 Neural Arch	3	100	0	-
Clefting S2 Neural Arch	1	100	0	-
Parietal Osteoma	1	100	0	-
Epipteric Ossicle	1	100	0	-
Posterior Condylar Canal	2	100	0	-
Anterior Condylar Canal	1	100	0	-
Maxillary Torus	2	100	0	-
Suprascapular Foramen	1	100	0	-
Bifid Rib	2	100	0	-
Femoral Osteoma	5	100	0	-
Femoral Supracondylar Process	2	100	0	-
Tibia Osteoma	1	100	0	-
Metatarsal Osteoma	1	100	0	-
Palatine Torus	0	-	1	100
Congenital Absence of Dentition	0	-	1	100
Supernumerary Dentition	0	-	1	100
Enamel Pearls	0	-	1	100
Cervicothoracic Cranial Border Shift	0	-	1	100
Extra Thoracic Vertebrae	0	-	1	100
Thoracolumbar Border Caudal Shift	0	-	1	100
Bifurcation of S2 Neural Arch	0	-	1	100
Coronal Osteoma	0	-	1	100
Sixth Cusp Mandibular Permanent 2nd Molar	0	-	1	100
Humeral Osteoma	0	-	2	100
Thirteenth Rib	0	-	1	100
Tibia Anteversion	0	-	1	100

n=Number of individuals

Table 30: Noticeable Percentage Differences for the St. Owen's Church Collection

		Males		Females	
Nonmetric Trait	**N**	**n**	**%**	**n**	**%**
Sagittal Ossicle	4	3	75	1	25
Sagittal Depression	3	2	66.7	1	33.3
Occipital Bun	37	13	35.1	24	64.9
Lumbosacral Border Shift Cranial	7	3	42.9	4	57.1
Frontal Foramen	19	14	73.7	5	26.3
Parietal Ossicle	3	2	66.7	1	33.3
Asterion Ossicle	5	3	60	2	40
Lambdoid Ossicle	24	15	62.5	9	37.5
Huschke Foramen	11	3	27.3	8	72.7
Foramen Ovale	8	6	75	2	25
Foramen Spinosum Open	6	5	83.3	1	16.7
Accessory Lesser Palatine Foramen	17	12	70.6	5	29.4
Mandibular Torus	3	1	33.3	2	66.7
Humeral Supracondylar Process	5	4	80	1	20
Flared Rib	3	2	66.7	1	33.3
Acetabular Crease	5	2	40	3	60
Allen's Fossa	10	4	40	6	60
Poirier's Facet	8	6	75	2	25
Squatting Facet	33	13	39.4	20	60.6

N=Total number of NMTs recorded, n=Number of individuals

The adult sample was further split into three age-at-death categories (18 to 24.99 (n=19), 25 to 44.99 (n=92) and 45+ (n=59) years of age). The percentage differences were often higher within the 25 to 44.99 age-at-death category although this is probably due to the large sample size in comparison to the other two groups. Nonetheless, most NMTs were evenly spread between the 25 to 44.99 and 45+ age-at-death category. Often, the percentage of some NMTs is small for the 18 to 24.99 year category in comparison to the other two categories. For example, metopism is recorded as present three times within this sample (6.8%), and the accessory clavicle facet is only recorded twice (12.5%) within the youngest age-at-death category. This result may appear interesting. However, the sample size for this category is much lower when compared to the sample size of the other categories. Identifying the distinct discrepancies observed identified here and with other NMTs. Nonetheless, an individual who exhibits a trait in early adulthood (18 to 24.99 years of age) are likely to retain the trait until later life. The non-adult sample was reviewed by their broader age-at-death categories (0 to 4.99 (n=66), 5 to 11.99 (n=15), and 12 to 17.99 (n=14) years of age). Similar to the Poulton Chapel Collection, the percentage differences were similar for almost all NMTs between 5 and 17.99 years of age. However, the youngest category (0 to 4.99 years of age) exhibited much lower percentages for the majority of NMTs recorded. For example, the squatting facet was recorded as present on two occasions (16.7%) for non-adults between 0 to 4.99 years of age. This is unsurprising as the appearance on the distal epiphysis of the tibia does not begin until approximately four years of age (Schaefer *et al.,* 2009). A commonality so far is that supernumerary sutural variants (e.g. coronal ossicle and lambdoid ossicle) are recorded for all age categories supporting El-Najjar and Dawson (1977) who identified the presence of sutural variants in foetal crania. Further care must be taken in the result interpretation as not all NMTs can be recorded as present in the 0 to 4.99 years of age category (e.g. the third molar or sternal aperture) as ontogeny is incomplete for these variants with the appearance of the traits not occurring until approximately eight years of age. Regardless, these results highlight an age-progressive nature to some NMTs, with the full expression not occurring until later life (e.g. the third molar) but others are present throughout ontogeny (e.g. supernumerary sutural bones) supporting previous comments made by Buikstra (1972) and Perizonous (1979).

5.3.2 Bilateral Differences

Bilateral differences were also explored for this collection. However, as found in the Poulton Chapel Collection, there was little or no difference in the percentage frequencies between left and right sides (see Table 27 and 28). Because of this, NMTs showing no side to side percentage differences were not subjected to further analysis. However, NMTs that presented a percentage differences (e.g. the supraorbital notch flared rib and squatting facet) were subjected to statistical analysis. A Chi-square test for independence was applied to identify if there is a difference between left and right sides for each NMT. This was applied to the entire sample where present '1' or absent '0' was scored. This test was repeated and applied to consider possible differences between the adult and non-adult sample, between the sexes and, between the age-at-death categories. All results presented p values over 0.05 identifying that there are no bilateral differences for any NMT within the St. Owen's Church sample.

5.3.3 Sex Differences

The comparison of sex was only applied to the St. Owen's Church adults (n=170). Here, it will be determined whether there are any statistical differences between the sexes that are significant. The percentage frequency of each NMT for the males (n=93) and the females (n=77) can be found in Appendix 6. For traits that were scored for both left and right sides, the highest score was used since this value represents that maximum expression of a specific NMT. A Mann-Whitney U test was applied to the categorical (present '1' and absent '0') data to explore any differences between the sexes for each NMT (n=126). For this data, no significant differences were found between the sexes for any NMT. In fact, the majority of NMTs showed no differences at all (p=1). Although no differences were found, these results are still interesting as there appears to be no sex bias in activity-related NMTs suggesting that the men and women buried at St. Owen's Church may have had similar lifestyles.

5.3.4 Age-at-death Differences

Here, the effects of age-at-death on the occurrence of 126 NMTs was explored. For ease of analysis, the non-adults and adults were grouped into broad age categories (For non-adults: 0 to 4.99 (n=66), 5 to 11.99 (n=15) and 12 to 17.99 (n=14) years of age. For adults: 18 to 24.99 (n=19), 25 to 44.99 (n=92) and 45+ (n=59) years of age). The percentage data for each NMT will be tested against each age-at-death category to determine if there are any statistically significant differences between the groups. For traits that were scored for both left and right sides, the highest score was used since this value represents that maximum expression of a specific NMT. The Kruskal-Wallis H Test was applied to the categorical (present '1' and absent '0') data to explore any differences between the age-at-death categories for each NMT (n=126). Ten NMTs showed a statistical significant difference between the six age-at-death categories for the St. Owen's Church sample (see Table 31). As previously mentioned in 3.7, this analysis cannot identify which groups are statistically significant from each other. To determine which groups differ, a one-way ANOVA and the Tukey's HSD post-hoc test was applied to these data.

Table 31: Results of the Kruskal-Wallis H Test for the St. Owen's Church sample

Nonmetric Trait	Kruskal-Wallis H Results (χ^2)
Huschke Foramen	$\chi^2(5) = 17.961$, p =0.003
Accessory Lesser Palatine Formation	$\chi^2(5) = 16.853$, p =0.005
Flared Rib	$\chi^2(5) = 14.698$, p =0.012
Hypertrochanteric Fossa	$\chi^2(5) = 14.502$, p =0.013
Vastus Notch	$\chi^2(5) = 49.727$, p =<0.001
Squatting Facet	$\chi^2(5) = 16.315$, p =0.006
Inferior Talus Single Articular Facet	$\chi^2(5) = 21.904$ p =0.001
Single Calcaneus Articular Facet	$\chi^2(5) = 22.400$, p =<0.001
Peroneal Tubercle	$\chi^2(5) = 13.746$, p =0.017
Metatarsal Osteoma	$\chi^2(5) = 22.625$, p =<0.001

Like the Kruskal-Wallis H Test, the one-way ANOVA test found a statistical difference between the six groups (F=61.270; p=<0.001). The Tukey's HSD test identified further significant differences between the 0 to 4.99 category and adults above 25 years of age (p=<0.001). Little difference was found between the remaining groups (p=0.684 to p=0.988). These tests were repeated using separate NMT categories (genetic, activity-related and ambiguous). All tests produced significant results (p=<0.001). A Tukey's HSD test was applied to age NMT category, and similar results were seen between each NMT category. Little or no differences were found between the three non-adult age-at-death categories (p=0.752 to p=986) and the 18 to 24.99 age at death category (p=0.401 to p=1). Like for the Poulton Chapel Collection, significant differences were reported between the non-adult and adult age-at-death categories (p=<0.001 to p=0.031). These results are expected due to the continuous development a non-adult skeleton is enduring. For this collection, it has already been reported that the non-adult sample exhibit fewer NMTs in comparison to the adult sample.

These tests were repeated just for the non-adult sample (0 to 4.99, 5 to 11.99 and 12 to 17.99 age-at-death categories). The Kruskal-Wallis H Test revealed a statistical difference for 11 NMTs (results ranging: $\chi^2(2)=6.404$ to 45.251, p=<0.041 to 0.05; see Appendix 7 for full details) between the three age-at-death categories for the St. Owen's Church sample. It is important to know which groups are statistically significant from each other. This was achieved by applying a one-way ANOVA and the Tukey's HSD post-hoc test to the data. Like the Kruskal-Wallis H Test, the one-way ANOVA test found a statistical difference between the three age-at-death categories ($F=9.217$; $p=<0.001$). The Tukey's HSD test identified further significant differences between the 0 to 4.99 and 5 to 11.99 age-at-death categories ($p=0.005$), and between the 0 to 4.99 and 12 to 17.99 age-at-death categories ($p=<0.001$). However, no significant difference was found between the 5 to 11.99 and 12 to 17.99 age-at-death category ($p=0.616$). These tests were repeated for the different NMT category (genetic, activity-related and ambiguous). Significant differences were found for the genetic ($F=27.646$; $p=<0.001$). The Tukey's HSD test identified significant differences between each age-at-death category ($p=<0.001$ to $p=0.001$). However, no significant differences were found for activity-related ($F=1.789$; $p=0.180$) or ambiguous ($F=1.807$; $p=0.173$) NMTs.

These tests were repeated just for the adult sample (18 to 24.99 (n=19), 25 to 44.99 (n=92) and 45+ (n=59) age-at-death categories). The Kruskal-Wallis H Test revealed a significant statistical difference for only three NMTs; the bifid rib, $\chi^2(2)=7.167$, $p=0.028$; the flared rib, $\chi^2(2)=8.551$, $p=0.014$; and finally, the third trochanter, $\chi^2(2)=6.993$, $p=0.030$. Although these skeletal variants have been highlighted with significant age differences, additional testing was not sought to identify which age-at-death categories presented significant statistical differences between the groups. This is due to previous statements by Hauser and De Stefano (1989) in accordance with other authors (Berry, 1975; and Perizonius, 1979) that all NMTs should be fully expressed by adulthood, excluding pre-puberty material, suggesting that any differences seen between the age categories above 25 years of age can be discounted.

5.4 The Norton Priory Collection

After the skeletal analysis of the Norton Priory Collection (n=130), the 126 NMTs were collated into simple frequency tables (see Table 32 and 33). Here, the data can be reviewed on a present/absent basis for all individuals and a preliminary review has identified that some NMTs appear more frequently than others.

Table 32: Frequency of the Cranial NMTs for the Norton Priory Collection

	Trait Score											
Nonmetric Trait	**1**	**0**	**9**	**1/1**	**1/0**	**0/1**	**1/9**	**9/1**	**0/9**	**9/0**	**0/0**	**9/9**
Metopism	35	51	44									
Supraorbital Foramen				21	9	10	3	5	2	3	36	41
Supraorbital Notch				28	10	7	0	2	4	6	32	41
Frontal Foramen				0	1	1	0	0	4	7	76	41
Zygomaticofacial Foramen				35	6	1	12	10	3	3	13	47
Accessory Infraorbital Foramen				29	1	0	3	1	0	1	28	67
Frontal Button Osteoma	6	88	36									
Frontal Bun	3	91	36									
Frontal Temporal Articulation				0	0	0	0	0	0	0	93	37
Bregmatic Ossicle	2	92	36									
Coronal Ossicle				1	1	6	0	0	3	0	83	36
Coronal Button Osteoma				0	1	0	0	0	3	0	90	36
Parietal Button Osteoma				1	1	1	0	0	3	0	90	34
Parietal Foramen				24	14	8	0	0	3	0	47	34
Auditory Torus				41	0	0	7	6	3	1	34	38
Mastoid Foramen				24	3	5	3	3	7	4	42	39
Sagittal Foramen	1	93	36									
Sagittal Ossicle	0	95	36									
Sagittal Bun	5	89	36									
Sagittal Depression	1	93	36									
Epipteric Ossicle				1	1	2	0	0	0	0	90	36
Parietal Notch Ossicle				0	1	1	0	0	1	0	92	35
Asterion Ossicle				5	2	4	0	0	1	0	83	35
Highest Nuchal line	0	100	31									
Ossicle at Lambda	14	84	32									
Lambdoid Ossicle				21	4	6	0	0	0	0	67	32
Occipital Bun	31	68	31									
Occipital Foramen	15	84	31									
Pars Basilaris Depression	1	64	65									
Precondylar Tubercle	2	63	65									
Occipital Osteoma	1	91	38									
Huschke Foramen				6	1	2	0	0	0	0	18	103
Posterior Condylar Canal				0	0	0	0	0	0	0	62	68
Occipital Condylar Facet				30	0	0	5	5	0	0	0	90

Skeletal variant scores: 1=Present, 0=Absent, 9=Unobservable. For bilateral traits, scores are given as left side/right side

Table 32: Continued…

				Trait Score								
Nonmetric Trait	**1**	**0**	**9**	**1/1**	**1/0**	**0/1**	**1/9**	**9/1**	**0/9**	**9/0**	**0/0**	**9/9**
Anterior Condylar Canal				1	0	0	0	0	0	0	51	78
Foramen Ovale				0	0	0	0	0	0	0	52	78
Foramen Spinosum Open				0	0	0	0	0	0	0	52	78
Accessory Lesser Palatine Foramen				2	0	0	0	0	0	0	65	63
Palatine Torus				3	2	1	0	0	3	12	62	47
Maxillary Torus				3	1	0	0	0	6	5	70	45
Mandibular Torus				1	3	5	0	1	3	5	80	32
Carabelli's Cusp Maxillary Deciduous 1st Molar				1	0	0	0	0	1	1	3	124
Carabelli's Cusp Mandibular Deciduos 1st Molar				3	0	0	0	0	0	0	2	125
Carabelli's Cusp Maxillary Permanent 1st Molar				4	0	0	2	2	7	7	38	70
Carabelli's Cusp Mandibular Permanent 1st Molar				11	1	0	1	1	6	5	40	65
Sixth Cusp Mandibular Permanent 2nd Molar				0	0	1	0	0	8	8	54	59
Maxillary Third Molar				29	2	0	3	6	0	1	23	66
Mandibular Third Molar				43	2	0	3	6	3	0	26	47
Peg Tooth	1	103	26									
Shovel Shaped Incisors	2	102	26									
Congenital Absence of Dentition	0	105	26									
Supernumerary Dentition	1	103	26									
Talan Cusp	1	103	26									
Late Eruption of Canines	2	102	26									
Enamel Pearls	0	105	26									

Skeletal variant scores: 1=Present, 0=Absent, 9=Unobservable. For bilateral traits, scores are given as left side/right side

Table 33: Frequency of the Postcranial NMTs for the Norton Priory Collection

	Trait Score											
Nonmetric Trait	**1**	**0**	**9**	**1/1**	**1/0**	**0/1**	**1/9**	**9/1**	**0/9**	**9/0**	**0/0**	**9/9**
Suprascapular Foramen				2	0	2	0	0	10	11	73	32
Acromial Articular Facet				0	1	0	0	0	10	11	76	32
Accessory Clavicle Facet				11	1	0	2	1	10	8	64	33
Sternal Aperture	1	44	85									
Humeral Supracondylar Process				1	0	0	0	0	11	6	88	24
Humeral Septal Aperture				3	4	4	0	0	11	6	78	24
Humeral Osteoma				0	0	0	0	0	11	5	90	24
Proximal Phalanx Osteoma				0	1	0	0	0	12	7	77	33
Single Atlas Articulating Facet	77	0	53	71	0	0	6	4	0	0	0	49
Double Atlas Articulating Facet	77	0	53	71	0	0	6	4	0	0	0	49
Occipitocervical Cranial Border Shift	0	83	48									
Bifurcation of C1 Neural Arch	2	79	49									
Clefting of C1 Neural Arch	0	81	50									
Bifurcation of C1 Anterior Neural Arch	0	82	49									
Block Fusion of C2 and C3	0	88	43									
Block Fusion of C3 and C4	1	85	44									
Block Fusion of C4 and C5	1	81	48									
Block Fusion of C5 and C6	0	83	48									
Block Fusion of C6 and C7	0	86	45									
Block Fusion of C7 and T1	1	84	45									
Cervicothoracic Cranial Border Shift	0	90	41									
Extra Thoracic Vertebrae	0	92	39									
Thirteenth Rib				0	0	0	0	0	0	0	2	128
Bifid Rib				0	0	0	0	0	0	1	90	39
Flared Rib				0	0	0	0	0	37	0	54	39
Congenital Absence of Thoracic Vertebrae	0	90	41									
Block Fusion of T7 and T8	2	86	42									
Block Fusion of T8 and T9	2	86	42									
Block Fusion of T9 and T10	2	86	42									
Block Fusion of T10 and T11	1	87	42									
Thoracolumbar Border Caudal Shift	2	86	42									
Lumbarisation of S1	4	82	44									
Sacralisation of L6	0	87	44									

Skeletal variant scores: 1=Present, 0=Absent, 9=Unobservable. For bilateral traits, scores are given as left side/right side

Table 33 Continued…

Nonmetric Trait	1	0	9	1/1	1/0	0/1	1/9	9/1	0/9	9/0	0/0	9/9
				Trait Score								
Spondylolysis of L6 Arch	0	3	128									
Bifurcation of L6 Neural Arch	0	3	128									
Clefting of L6 Neural Arch	0	3	128									
Accessory Lumbar Facet	0	88	43									
Bifurcation of S1 Neural Arch	5	69	56									
Clefting of S1 Neural Arch	4	70	56									
Bifurcation of S2 Neural Arch	1	54	75									
Clefting of S2 Neural Arch	3	52	75									
Spina Bifida Occulta	10	53	67									
Accessory Sacral Facet				9	2	3	1	0	6	7	71	31
Ilium Foramen				61	0	1	6	5	2	2	25	28
Sacroiliac Joint Fusion				1	2	1	0	0	8	6	80	32
Acetabular Crease				2	0	1	0	0	9	8	79	31
Femoral Osteoma				0	0	1	0	0	11	3	88	27
Femoral Supracondylar Process				0	0	0	0	0	11	3	90	26
Femoral Anteversion				0	1	2	0	0	11	3	87	26
Allen's Fossa				1	0	0	1	0	9	6	76	37
Poirier's Facet				3	0	3	0	0	10	6	71	37
Plaque Formation				4	0	1	0	0	10	6	72	37
Hypertrochanteric Fossa				39	3	2	7	2	2	2	43	30
Third Trochanter				11	1	2	2	0	8	4	72	30
Vastus Notch				4	0	0	2	3	8	9	36	68
Tibia Anteversion				1	0	1	0	0	8	5	83	32
Tibia Osteoma				1	1	1	0	0	8	5	82	32
Squatting Facet				17	1	2	5	5	2	3	38	57
Inferior Talus Single Articular Facet				60	0	0	6	3	0	0	0	61
Inferior Talus Double Articular Facet				60	0	0	6	3	0	0	0	61
Single Calcaneal Articular Facet				63	0	0	5	3	0	0	0	59
Double Calcaneal Articular Facet				63	0	0	5	3	0	0	0	59
Peroneal Tubercle				8	0	1	0	0	3	1	51	66
Metatarsal Osteoma				0	0	0	0	0	2	0	62	66

Skeletal variant scores: 1=Present, 0=Absent, 9=Unobservable. For bilateral traits, scores are given as left side/right side

Here, the frequency of the total number of skeletal variants expressed in a single individual is shown in Figure 28. The frequency patterns seen here are different to those seen in Figure 26 and 27, but this is due to bias in sample size for non-adults, males and females. However, some familiarities to Poulton Chapel and St. Owen's Church can be seen regarding less skeletal variants recorded for the non-adult remains in comparison to the adults. The following section explores any significant differences in bilateral asymmetry, sex and age differences for all skeletal variants with the Norton Priory collection. As mentioned earlier, there is an occurrence of intertrait associations between some NMTs, some of which are to be expected (e.g. metopism and ossicle at lambda). Previous research often focuses on NMTs on an individual basis. However, this does not mean that they are necessarily independent. This thesis reviews each trait on an independent level; however, a review of various intertrait associations are being considered for future research (see Chapter 7.4).

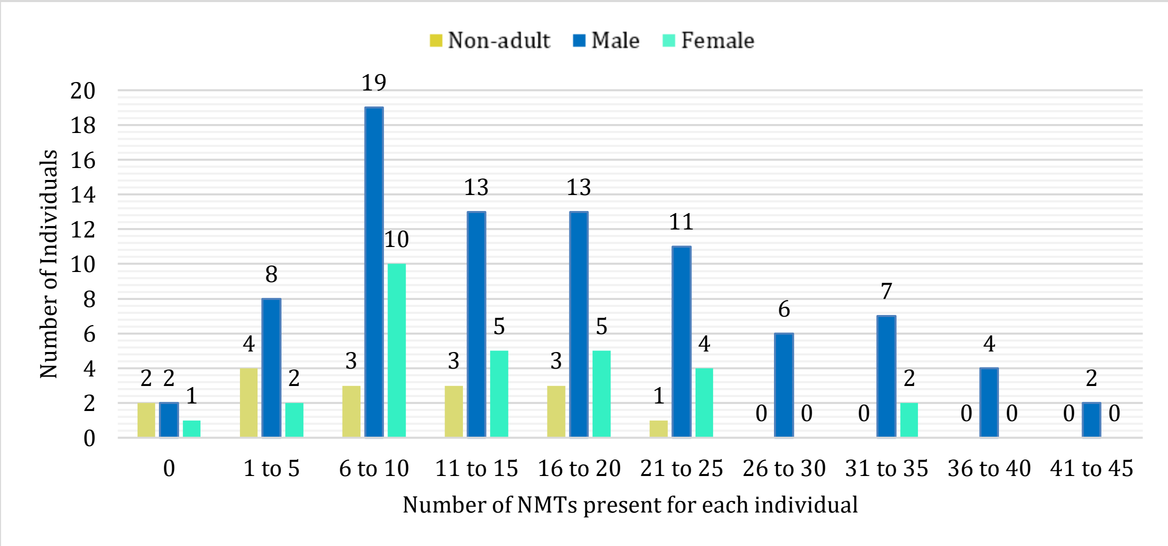

Figure 28: Frequency of NMTs for the Norton Priory Collection

5.4.1 Percentage Differences

Preliminary percentage overviews were made between the non-adult (n=16) and adult (n=114) sample, with the adult sample further defined by sex (males: n=85, females: n=29). Further details can be found in the Appendix (see Appendix 8). Unsurprisingly, the majority of NMTs were reported for the male sample. However, there is a distinct discrepancy between the sexes for this collection which must be considered. Here, 34 NMTs were only reported as present for the male sample while seven different NMTs were only reported for the female sample (see Table 34). Although such differences observed between the sexes and these NMTs, one must be careful with the interpretation of such small sample sizes and such biases between the sample sizes of the sexed sample

Table 34: Occurrence of NMTs within a single sex for the Norton Priory Collection

	Males		Females	
Nonmetric Trait	**n**	**%**	**n**	**%**
Bregmatic Ossicle	2	100	0	-
Sagittal Bun	5	100	0	-
Pars Basilaris Depression	1	100	0	-
Precondylar Tubercle	2	100	0	-
Occipital Osteoma	1	100	0	-
Peg Tooth	1	100	0	-
Shovel Shaped Incisors	2	100	0	-
Supernumerary Dentition	1	100	0	-
Talan Cusp	1	100	0	-
Sternal Aperture	1	100	0	-
Block Fusion of C3 and C4	1	100	0	-
Block Fusion of C4 and C5	1	100	0	-
Block Fusion of C7 and T1	1	100	0	-
Block Fusion of T7 and T8	2	100	0	-
Block Fusion of T8 and T9	2	100	0	-
Block Fusion of T9 and T10	2	100	0	-
Block Fusion of T10 and T11	1	100	0	-
Lumbarisation of S1	3	100	0	-
Spondylolysis of L4 Neural Arch	1	100	0	-
Spondylolysis of L5 Neural Arch	3	100	0	-
Bifurcation of L5 Neural Arch	1	100	0	-
Coronal Osteoma	1	100	0	-
Anterior Condylar Canal	1	100	0	-
Accessory Lesser Palatine Foramen	2	100	0	-
Maxillary Torus	4	100	0	-
Mandibular Torus	10	100	0	-
Sixth Cusp Mandibular Permanent 2nd Molar	1	100	0	-
Femoral Supracondylar Process	1	100	0	-
Acetabular Crease	3	100	0	-
Femoral Anteversion	1	100	0	-
Plaque Formation	5	100	0	-
Vastus Notch	9	100	0	-
Tibia Anteversion	1	100	0	-
Tibia Osteoma	3	100	0	-
Sagittal Foramen	0	-	1	100
Sagittal Depression	0	-	1	100
Thoracolumbar Border Shift Caudal	0	-	2	100
Bifurcation of S2 Neural Arch	0	-	1	100
Acromial Articular Facet	0	-	1	100
Proximal Phalanx Osteoma	0	-	1	100
Femoral Osteoma	0	-	1	100

n=Number of individuals

Forty-one NMTs presented notable percentage differences between the sexes (see Table 35). For all 41 NMTs, the percentage difference between the sexes were highly favoured to the male sample. The interpretation of these results is limited due to the discrepancy between the total sample size of the male and female sample. The adult sample was further split into three age-at-death categories (18 to 24.99 (n=19), 25 to 44.99 (n=92) and 45+ (n=59) years of age). The percentage differences were evenly spread for all NMTs between the 25 to 44.99 and 45+ age-at-death category. However, the youngest category (18 to 24.99 years) exhibited differences for numerous NMTs.

For example, parietal foramen was present in only 3% of adults in the youngest age-at-death category, while 64% were between 24 to 44.99 years of age and 33% of adults fell within the oldest category. This is unsurprising as the sample size for the youngest age-at-death category is much lower in comparison to the sample size of the other two categories. The sample demographics for the Norton Priory is unique in comparison to the other samples used in this thesis (see Chapter 4). Separately, the non-adult sample was reviewed further by their broad age-at-death categories (0 to 4.99 (n=7), 5 to 11.99 (n=5), and 12 to 17.99 (n=4) years of age). The percentage differences were variable between each age-at-death category for most NMTs. An issue for this sample is firstly, the overall sample size for each category is very small. Secondly, the preservation of the non-adult remains from Norton is very poor affecting the possibility of all NMTs to be recorded. As a collective review, most NMTs are often higher for the older age-at-death categories (5 and 17.99 years of age) supporting the previous statements to the progressive nature of selective NMTs, with the full expression not occurring until later life (Buikstra, 1972; Berry, 1975; and Perizonous, 1979).

Table 35: Noticeable Percentage Differences for the Norton Priory Collection

		Males		Females	
Nonmetric Trait	**N**	**n**	**%**	**n**	**%**
Metopism	34	29	85.3	5	14.7
Frontal Button Osteoma	6	5	83.3	1	16.7
Ossicle at Lambda	12	8	66.7	4	33.3
Occipital Bun	30	22	73.3	8	26.7
Extra Lumbar Vertebrae	3	2	66.7	1	33.7
Bifurcation of S1 Neural Arch	5	2	40	3	60
Clefting of S1 Neural Arch	3	2	66.7	1	33.3
Spina Bifida	9	6	66.7	3	33.3
Supraorbital Foramen	44	35	79.5	9	20.5
Supraorbital Notch	43	34	79.5	9	20.5
Zygomaticofacial Foramen	59	48	81.4	11	18.6
Coronal Ossicle	8	6	75	2	25
Parietal Foramen	43	35	81.4	8	18.6
Auditory Torus	51	42	82.3	9	17.7
Mastoid Foramen	36	30	83.3	6	16.7
Epipteric Ossicle	3	2	66.7	1	33.3
Asterion Ossicle	10	8	80	2	20
Lambdoid Ossicle	30	23	76.7	7	23.3
Accessory Clavicle Facet	15	13	86.7	2	13.3
Humeral Septal Aperture	11	8	72.7	3	27.3
Accessory Sacral Facet	13	11	84.6	2	15.4
Poirier's Facet	6	5	83.3	1	16.7
Hypertrochanteric Fossa	50	42	84	8	16
Third Trochanter	15	11	73.3	4	26.7
Squatting Facet	28	20	71.4	8	28.6

N=Total number of NMTs recorded, n=Number of individuals

5.4.2 Bilateral Differences

Bilateral differences were also explored for this collection. However, little or no difference was found in the percentage frequencies between left and right sides (see Table 32 and 33). Because of this, NMTs that showed no percentage difference were not subjected to analysis. Nonetheless, NMTs that presented slight percentage differences between both left and right sides (e.g. the zygomaticofacial foramen and parietal foramen) were subjected to these analyses. A Chi-square test for independence was applied to identify if there is a difference between left and right sides for individual NMTs. This was applied to the entire sample were '1' or '0' was scored. Additional tests were applied to consider possible differences between adult and non-adults, between the sexes, and between age-at-death categories. As seen for the other two sample sites, the results presented p values over 0.05, indicating no significant differences between sides.

5.4.3 Sex Differences

The comparison of sex was only applied to the Norton Priory adults (n=114). Here, it will be determined whether there are any statistical differences between the sexes that are significant. The percentage frequency of each NMT for the males (n=85) and the females (n=29) can be found in Appendix 8. For traits that were scored for both left and right sides, the highest score was used since this value represents that maximum expression of a specific NMT. A Mann-Whitney U test was applied to the categorical data to explore any differences between the sexes for each NMT (n=126). Overall, most NMTS presented no significant results. However, five NMTs did present a significant difference between the sexes; the zygomaticofacial foramen (U=348.000, Z=-2.304, p=0.021); auditory torus (U=414.000, Z=-2.023, p=0.043); the maxillary third molar (U=178.00, Z=-2.015, p=0.044); the thoracolumbar border caudal shift (U=518.000, Z=-2.550, p=0.011) and finally, the bifurcation of S1 neural arch (U=327.000, Z=-2.082, p=0.037). All NMTs ranked highest within the male sample. It must be noted that these results are significant due to the set level of p<0.05 for significance. However, if the Bonferroni adjusted value is applied to these results (p=0.00039683), there are no statistically significant differences between the sexes for any NMT.

5.4.4 Age-at-death Differences

Here, the effects of age-at-death on the occurrence of 126 NMTs was explored. For ease of analysis, the non-adults and adults were grouped into broad age categories (For non-adults: 0 to 4.99 (n=7), 5 to 11.99 (n=5) and 12 to 17.99 (n=4) years of age. For adults: 18 to 24.99 (n=4), 25 to 44.99 (n=67) and 45+ (n=43) years of age). The percentage data for each NMT will be tested against each age-at-death category to determine if there are any statistically significant differences between the groups. For traits that were scored for both left and right sides, the highest score was used since this value represents that maximum expression of a specific NMT. The Kruskal-Wallis H Test was applied to the categorical (present '1' and absent '0') data to explore any differences between the age-at-death categories for each NMT (n=126). For this sample, 33 NMTs showed a significant difference between the six age-at-death categories (results ranging: $\chi^2(5)=11.230$ to 58.850, $p=<0.001$ to 0.047; data not shown). As this test cannot identify which groups are different to each other, a one-way ANOVA and the Tukey's HSD post-hoc test was be applied to these data (see 3.7). Like the Kruskal-Wallis H Test, the one-way ANOVA test found a significant difference was found between the six groups ($F=189.380$; $p=<0.001$). A Tukey's HSD test identified further significant differences between some of the age-at-death categories specifically between the 0 to 4.99 category and adults above 25 years of age ($p=<0.001$). Little difference was found for the remaining age-at-death categories ($p=0.890$ to $p=0.998$). These tests were repeated using separate NMT categories (genetic, activity-related and ambiguous). All tests produced statistical significant results; genetic NMTs ($F=62.716$; $p=<0.001$), activity-related NMTs ($F=87.631$; $p=<0.001$) and finally, ambiguous NMTs ($F=81.545$; $p=<0.001$). A Tukey's HSD test was applied to age NMT category, and similar results were seen between each NMT category. Little or no differences were found between the three non-adult age-at-death categories ($p=0.981$ to $p=1$). Little or some differences were found between the three non-adult age-at-death categories and the 18 to 24.99 year category ($p=0.570$ to $p=0.999$). Finally, significant differences were reported between the non-adult and adult over 25 years of age ($p=<0.001$). This difference observed between the non-adult and adult samples is to be expected due to the morphological differences previously mentioned.

These tests were repeated just for the non-adult sample (0 to 4.99, 5 to 11.99 and 12 to 17.99 age-at-death categories). The Kruskal-Wallis H Test revealed a significant statistical difference for one NMT, the Mandibular Third Molar, $\chi^2(2)=6.429$, $p=0.040$ between the three age-at-death categories for the Norton Chapel sample. It is important to know which age-at-death groups are statistically significant from each other. This was achieved by applying a one-way ANOVA and the Tukey's HSD post-hoc test to the data. Like the Kruskal-Wallis H Test, the one-way ANOVA test found that a statistical difference was found (F=12.562; p=<0.001). The Tukey's HSD test identified further significant differences between the 0 to 4.99 and 12 to 17.99 age-at-death categories (p=<0.001).

These tests were repeated just for the adult sample (18 to 24.99 (n=19), 25 to 44.99 (n=92) and 45+ (n=59). The Kruskal-Wallis H Test revealed a significant statistical difference for 34 NMTs between the three age-at-death categories (data not shown). Although these skeletal variants have been highlighted with significant age differences, additional testing was not sought to identify which age-at-death categories presented significant statistical differences between the groups. This is due to previous statements by Hauser and De Stefano (1989) and other authors (e.g: Berry, 1975; and Perizonius, 1979) who state that all NMTs should be fully expressed by adulthood, excluding pre-puberty material, suggesting that any differences seen between the age categories above 25 years of age can be discounted.

5.5 Intra-Population Analysis

Presented here is the statistical analysis of the 126 NMTs recorded from within the Poulton Chapel (n=602), St. Owen's Church (n=265) and the Norton Priory (n=130) Collections. The Kruskal-Wallis H Test was applied to the categorical (present '1' and absent '0') data to explore any differences between the three samples for each NMT (n=126). Seventy-six NMTs showed a significant difference between the three samples sites (data not shown). Unfortunately, this test cannot identify which groups are different from each other. To determine which groups are different to each other a one-way ANOVA and the Tukey's HSD post-hoc test will be applied to the data (see 3.7). Like the Kruskal-Wallis H Test, the one-way ANOVA test found a statistical difference for the same 76 NMTs. Here, NMTs that displayed a significant difference between the three skeletal collections were further reviewed. Overall, 13 NMTs presented a significant difference between the Poulton Chapel, St. Owen's Church and Norton Priory Collections (see Table 36). Upon further review of the results, St. Owen's Church and Norton Priory show little or no difference between the presence of 26 NMTs (see Table 37), suggesting that these NMTs occur more frequently within the Poulton Chapel Collection.

Table 36: NMTs that displayed a significant difference between the three sites

Nonmetric Trait	POU & SOC	POU & NP	NP & SOC
Supraorbital Foramen	<0.001	<0.001	0.020
Parietal Button Osteoma	<0.001	<0.001	0.009
Occipital Osteoma	<0.001	<0.001	<0.001
Occipital Condylar Facet	<0.001	<0.001	0.009
Accessory Lesser Palatine Foramen	<0.001	<0.001	0.002
Mandibular Torus	<0.001	0.005	<0.001
Sixth Cusp Mandibular Permanent 2nd Molar	<0.001	<0.001	<0.001
Suprascapular Foramen	<0.001	<0.001	0.032
Bifurcation of S2 Neural Arch	<0.001	<0.001	<0.001
Clefting of S2 Neural Arch	<0.001	<0.001	<0.001
Poirier's Facet	<0.001	<0.001	0.034
Single Calcaneal Articular Facet	<0.001	0.009	<0.001
Peroneal Tubercle	<0.001	<0.001	0.006

POU=Poulton Chapel, SOC=St. Owen's Church, NP=Norton Priory

Table 37: NMTs more common in the Poulton Chapel sample

Nonmetric Trait	POU & SOC	POU & NP	NP & SOC
Zygomaticofacial Foramen	<0.001	<0.001	0.122
Accessory Infraorbital Foramen	<0.001	<0.001	0.506
Frontal Button Osteoma	0.010	0.001	0.778
Parietal Foramen	<0.001	<0.001	0.799
Auditory Torus	<0.001	<0.001	0.327
Highest Nuchal line	<0.001	<0.001	0.556
Ossicle at Lambda	<0.001	<0.001	0.076
Huschke Foramen	<0.001	<0.001	0.586
Carabelli's Cusp Mandibular Deciduos 1st Molar	<0.001	<0.001	0.376
Maxillary Third Molar	<0.001	<0.001	0.872
Mandibular Third Molar	<0.001	<0.001	0.940
Late Eruption of Canines	0.042	0.003	0.498
Sternal Aperture	0.012	0.003	0.810
Humeral Septal Aperture	<0.001	0.022	0.921
Single Atlas Articulating Facet	<0.001	<0.001	0.853
Double Atlas Articulating Facet	<0.001	<0.001	1.000
Block Fusion of T9 and T10	<0.001	0.047	0.684
Ilium Foramen	<0.001	<0.001	0.898
Femoral Supracondylar Process	0.001	<0.001	0.435
Allen's Fossa	<0.001	<0.001	0.155
Hypertrochanteric Fossa	<0.001	<0.001	0.939
Third Trochanter	<0.001	<0.001	0.840
Vastus Notch	<0.001	<0.001	0.940
Tibia Anteversion	<0.001	<0.001	1.000
Tibia Osteoma	<0.001	<0.001	1.000
Inferior Talus Single Articular Facet	<0.001	<0.001	0.994

POU=Poulton Chapel, SOC=St. Owen's Church, NP=Norton Priory

On the other hand, St. Owen's Church share eight NMTs with the Poulton Chapel Collection (see Table 38) suggesting that these NMTs are frequently found within the Norton Priory Collection. Lastly, the Poulton Chapel and Norton Priory show little or no difference in occurrence for 27 NMTs suggesting that these traits are particular to the St. Owen's Church Collection. This high frequency of similar traits between Poulton Chapel and the Norton Priory Collection is probably due to the geographic location of these two sites (see Chapter 2). These two sites are closely related to one another in the northwest of England in comparison to the St. Owen's Church Collection, which is located much further south. This suggests the possibility of a regional divide between the north and southern site. To conclude, two NMTs, the asterion ossicle and lumbarisation of S1 were identified with a significant statistical difference between the three sample sites for the Kruskal-Wallis H Test and similarly for the one-way ANOVA test (p=0.041). Unfortunately, when subjected to the Tukey's HSD Test, no difference was found between the multiple comparisons.

Table 38: NMTs more common in the Norton Priory sample

Nonmetric Trait	POU & SOC	POU & NP	NP & SOC
Bregmatic Ossicle*	0.939	<0.001*	<0.001*
Sagittal Depression*	0.996	0.009*	0.040*
Parietal Notch Ossicle	0.642	<0.001*	0.019*
Maxillary Torus	0.243	<0.001*	0.004*
Carabelli's Cusp Mandibular Permanent 1st Molar	0.872	0.022*	0.036*
Acetabular Crease	0.935	0.002*	0.003*
Squatting Facet	0.317	<0.001*	<0.001*
Metatarsal Osteoma	0.714	0.001*	<0.001*

POU=Poulton Chapel, SOC=St. Owen's Church, NP=Norton priory *Significant p<0.05

Exploration of the effects of age-at-death and sex between the NMTS of these three collections was considered. However, this would lead to inconclusive results. There is a distinct difference between the sample sizes for each collection. For example, the samples sizes between the sexes for the Poulton Chapel and St. Owen's Church Collection are reasonably even. However, there is a high frequency of males in the Norton Priory Collection, with few females. A further note is that the total adult sample size for each collection varies dramatically. This is reflected in the age-at-death categories, especially for the Norton Priory Collection were very few non-adults were observed. For these reasons, comparisons between these three collections were not attempted.

5.6 Comparative Assemblages

The percentage frequency of 126 cranial and postcranial NMTs from the Poulton Chapel, St. Owen's Church and Norton Priory samples will be compared to nine comparative skeletal assemblages; the Wharram Percy (WP), Hirsel (HIR), Monkwearmouth (MK), Jarrow (JA), Blackgate (BG), Blackfriars (BF), St. Brides (SB), Spitalfields (SPC) and the Terry (TC) Collections (see Table 39 and 40). The original aim was to review how these samples fit within Medieval Britain. However, finding comparison data that record the 126 NMTs included in this thesis, a reasonable sample size and are Medieval in origin was challenging. This led to using comparative assemblages derived from collections across the UK and one from North America. These comparative collections range from the Prehistoric to Modern. Overall, it was possible to find comparative data for 44% of the NMTs recorded in the Poulton Chapel, St. Owen's Church and Norton Priory Collections. That includes 54.5% cranial and 36.6% postcranial NMTs.

Table 39: Comparative samples in percentages: Cranial NMTs

Nonmetric Trait	POU	SOC	NP	WP	HIR	MK	JA	BG	BF	SB	SPC	TC
Metopism	29.2	22.6	26.9	10.4	5.6	4.5	3.8	12.5	9.5	3.3	9	7.2
Supraorbital Foramen	13.6	15.8	25.4	29	-	-	-	-	-	-	15	40.3
Supraorbital Notch	32.4	25.3	29.2	-	-	-	-	-	-	-	-	-
Frontal Foramen	1.2	8.3	0.8	-	-	-	-	-	-	57.1	80	41
Zygomaticofacial Foramen	6.5	21.9	40.8	89.4	-	-	-	-	-	12.6	53	93.4
Accessory Infraorbital Foramen	6.3	16.6	25.4	20.8	-	-	-	-	-	3.3	85	19.4
Frontal Button Osteoma	1.0	3.0	4.6	-	-	-	-	-	-	-	-	-
Frontal Bun	0	0	2.3	-	-	-	-	-	-	-	-	-
Frontal Temporal Articulation	0	0	0	2	-	-	-	-	-	0	-	-
Bregmatic Ossicle	0.3	0	1.5	0.4	-	-	-	-	-	0.5	2	0
Coronal Ossicle	0.2	0.4	1.5	1.3	7.8	2.4	4.2	10	4.3	0	12	2.9
Coronal Button Osteoma	0.2	0.4	0.8	-	-	-	-	-	-	-	-	-
Parietal Button Osteoma	0.5	0.8	1.5	-	-	-	-	-	-	-	-	-
Parietal Foramen	13.1	13.2	29.2	70.2	70.1	50	66.7	48.5	63.6	61.5	68	50
Auditory Torus	5.0	31.3	36.9	0	-	-	-	-	-	-	-	-
Mastoid Foramen	1.5	14.7	23.1	56.8	-	-	-	-	-	36.8	26	80.9
Sagittal Foramen	0.2	0.8	0.8	-	-	-	-	-	-	-	-	-
Sagittal Ossicle	0.7	1.9	0	2.3	9.6	3.4	2.0	20.7	0	-	3	2.9
Sagittal Bun	1.0	0.8	3.8	-	-	-	-	-	-	-	-	-
Sagittal Depression	0.5	1.1	0.8	-	-	-	-	-	-	-	-	-
Epipteric Ossicle	0.3	0.4	1.5	16	14.5	2.5	0	10	0	8.8	7	23
Parietal Notch Ossicle	1.8	1.5	0.8	15.2	3.6	25	0	18.2	5.9	6.7	27	23
Asterion Ossicle	1.7	2.3	5.4	12	8.8	12.5	10.5	11.1	8.7	10.4	24	21.6
Highest Nuchal line	0.0	0.4	0	-	-	-	-	-	-	13.7	45	-
Ossicle at Lambda	4.3	6.4	10.8	16.7	-	-	-	-	-	7.6	9	10.1
Lambdoid Ossicle	11.1	7.5	19.2	47.4	56.7	50	30.6	73.3	73.9	23.1	34	32.4
Occipital Bun	15.8	21.9	23.8	-	-	-	-	-	-	-	-	-
Occipital Foramen	0.3	4.5	11.5	-	-	-	-	-	-	-	-	-
Pars Basilaris Depression	0.2	2.6	0.8	-	-	-	-	-	-	-	-	-
Precondylar Tubercle	0.3	0	1.5	8.4	0	4	4	13.8	4.8	4.9	80	28.8
Occipital Osteoma	0.7	1.1	0.8	-	-	-	-	-	-	-	-	-
Huschke Foramen	0.7	5.7	5.4	21.2	-	-	-	-	-	8.8	2	46
Posterior Condylar Canal	11.8	0.8	0	77.7	23.3	19.2	54.5	9.1	0	26.4	64	97.8
Occipital Condylar Facet	11.8	32.8	26.9	-	-	-	-	-	-	0.5	-	-

POU=Poulton Chapel, SOC=St. Owen's Church, NP=Norton Priory, WP=Wharram Percy, HIR=Hirsel, MK=Monkwearmouth, JA=Jarrow, BG=Blackgate, BF=Blackfriars, SB=St. Brides (SB), SPC=Spitalfields, TC=Terry Collection

Table 39 Continued…

Nonmetric Trait	POU	SOC	NP	WP	HIR	MK	JA	BG	BF	SB	SPC	TC
Anterior Condylar Canal	0.7	0.8	0.8	-	-	-	-	-	-	21.9	-	-
Foramen Ovale	0.0	0	0	6.4	-	-	-	-	-	1.1	1	82
Foramen Spinosum Open	0.0	1.9	0	-	-	-	-	-	-	3.3	-	-
Accessory Lesser Palatine Foramen	51.0	0.8	1.5	82.1	-	-	-	-	-	64.3	-	-
Palatine Torus	0.0	0.4	3.8	5.7	21	20	0	19.1	15.8	40.6	1	23.7
Maxillary Torus	0.3	0.4	3.1	0.9	12.4	10	0	14.3	26.1	4.4	15	6.5
Mandibular Torus	0.5	1.5	3.1	0.8	0.9	0	0	29.8	0	-	3.5	7.2
Carabelli's Cusp Maxillary Deciduous 1st Molar	2.8	2.3	0.8	-	-	-	-	-	-	-	-	-
Carabelli's Cusp Mandibular Deciduos 1st Molar	16.3	8.3	2.3	-	-	-	-	-	-	-	-	-
Carabelli's Cusp Maxillary Permanent 1st Molar	4.5	3.4	4.6	-	-	-	-	-	-	-	-	-
Carabelli's Cusp Mandibular Permanent 1st Molar	26.7	11.7	10.0	-	-	-	-	-	-	-	-	-
Sixth Cusp Mandibular Permanent 2nd Molar	0.5	0.4	0	-	-	-	-	-	-	-	-	-
Maxillary Third Molar	22.8	16.6	26.2	-	-	-	-	-	-	-	-	-
Mandibular Third Molar	30.2	24.2	36.9	-	-	-	-	-	-	-	-	-
Peg Tooth	1.8	1.1	0.8	-	-	-	-	-	-	-	-	-
Shovel Shaped Incisors	2.7	0.4	1.5	-	-	-	-	-	-	-	-	-
Congenital Absence of Dentition	0.5	0.4	0	-	-	-	-	-	-	-	-	-
Supernumerary Dentition	0.3	0.4	0.8	-	-	-	-	-	-	-	-	-
Talan Cusp	0.3	0	0.8	0.3	-	-	-	-	-	-	-	-
Late Eruption of Canines	0.2	0.4	1.5	-	-	-	-	-	-	-	-	-
Enamel Pearls	0.0	0.4	0	1.5	-	-	-	-	-	-	-	-

POU=Poulton Chapel, SOC=St. Owen's Church, NP=Norton Priory, WP=Wharram Percy, HIR=Hirsel, MK=Monkwearmouth, JA=Jarrow, BG=Blackgate, BF=Blackfriars, SB=St. Brides (SB), SPC=Spitalfields, TC=Terry Collection

Table 40: Comparative samples in percentages: Postcranial NMTs

Nonmetric Trait	POU	SOC	NP	WP	HIR	MK	JA	BG	BF	SB	SPC	TC
Suprascapular Foramen	1.2	1.1	1.5	4.8	-	-	-	-	-	-	-	-
Acromial Articular Facet	0	0	0.8	6.1	-	-	-	-	-	-	-	-
Accessory Clavicle Facet	3.8	9.1	10.8	-	-	-	-	-	-	-	-	-
Sternal Aperture	0.2	0.4	0.8	-	-	-	-	-	-	-	-	-
Humeral Supracondylar Process	0.7	2.3	0.8	1.1	-	-	-	-	-	-	-	-
Humeral Septal Aperture	4.5	3.4	5.4	9.7	4.5	10.7	8.5	18.5	3.6	-	-	-
Humeral Osteoma	0	0.8	0	-	-	-	-	-	-	-	-	-
Proximal Phalanx Osteoma	0	0	0.8	-	-	-	-	-	-	-	-	-
Single Atlas Articulating Facet	54.5	36.2	59.2	-	-	-	-	-	-	-	-	-
Double Atlas Articulating Facet	10.0	0	0	13.9	13.9	5.1	0	16.7	25	-	-	-
Occipitocervical Cranial Border Shift	0.2	0	1.5	1.2	-	-	-	-	-	-	-	-
Bifurcation of C1 Neural Arch	0.3	0	0	-	-	-	-	-	-	-	-	-
Clefting of C1 Neural Arch	0.7	0	0	-	-	-	-	-	-	-	-	-
Bifurcation of C1 Anterior Neural Arch	0.2	0	0	-	-	-	-	-	-	-	-	-
Block Fusion of C2 and C3	1.3	0	0.8	1.5	-	-	-	-	-	-	-	-
Block Fusion of C3 and C4	0	0	0.8	0.4	-	-	-	-	-	-	-	-
Block Fusion of C4 and C5	0	0.4	0	-	-	-	-	-	-	-	-	-
Block Fusion of C5 and C6	0	0	0	0.4	-	-	-	-	-	-	-	-
Block Fusion of C6 and C7	0.5	0	0.8	0.4	-	-	-	-	-	-	-	-
Block Fusion of C7 and T1	0	0.4	0	-	-	-	-	-	-	-	-	-
Cervicothoracic Cranial Border Shift	0	0.4	0	-	-	-	-	-	-	-	-	-
Extra Thoracic Vertebrae	0.3	0.4	0	-	-	-	-	-	-	-	-	-
Thirteenth Rib	0.3	0.8	0	-	-	-	-	-	-	-	-	-
Bifid Rib	0	0.4	0	-	-	-	-	-	-	-	-	-
Flared Rib	0	0	0	-	-	-	-	-	-	-	-	-
Congenital Absence of Thoracic Vertebrae	0.2	0.4	1.5	-	-	-	-	-	-	-	-	-
Block Fusion of T7 and T8	0.3	0.4	1.5	0.8	-	-	-	-	-	-	-	-
Block Fusion of T8 and T9	0.3	0.4	1.5	-	-	-	-	-	-	-	-	-
Block Fusion of T9 and T10	0.3	0	0.8	-	-	-	-	-	-	-	-	-
Block Fusion of T10 and T11	0.2	0.4	1.5	-	-	-	-	-	-	-	-	-
Thoracolumbar Border Caudal Shift	0.3	3.4	3.1	-	-	-	-	-	-	-	-	-
Lumbarisation of S1	0.3	0.4	0	27	-	-	-	-	-	-	-	-

POU=Poulton Chapel, SOC=St. Owen's Church, NP=Norton Priory, WP=Wharram Percy, HIR=Hirsel, MK=Monkwearmouth, JA=Jarrow, BG=Blackgate, BF=Blackfriars, SB=St. Brides (SB), SPC=Spitalfields, TC=Terry Collection

Table 40 Continued…

Nonmetric Trait	POU	SOC	NP	WP	HIR	MK	JA	BG	BF	SB	SPC	TC
Sacralisation of L6	0	0	0	-	-	-	-	-	-	-	-	-
Spondylolysis of L6 Arch	0.2	0	0	1.2	-	-	-	-	-	-	-	-
Bifurcation of L6 Neural Arch	0	0.8	0	-	-	-	-	-	-	-	-	-
Clefting of L6 Neural Arch	0	0	0	-	-	-	-	-	-	-	-	-
Accessory Lumbar Facet	0.7	5.7	3.8	-	-	-	-	-	-	-	-	-
Bifurcation of S1 Neural Arch	1.5	1.1	3.1	-	-	-	-	-	-	-	-	-
Clefting of S1 Neural Arch	1.2	0.8	0.8	-	-	-	-	-	-	-	-	-
Bifurcation of S2 Neural Arch	0	0.8	2.3	-	-	-	-	-	-	-	-	-
Clefting of S2 Neural Arch	0.8	13.6	7.7	-	-	-	-	-	-	-	-	-
Spina Bifida Occulta	5.3	17.7	9.2	3.1	-	-	-	-	-	-	-	-
Accessory Sacral Facet	6.0	66.8	51.5	12.5	-	-	-	-	-	-	-	-
Ilium Foramen	13.0	1.5	2.3	-	-	-	-	-	-	-	-	-
Sacroiliac Joint Fusion	0.5	1.1	1.5	-	-	-	-	-	-	-	-	-
Acetabular Crease	0.2	1.1	0	16.4	10.4	0	21.1	37.8	4	-	-	-
Femoral Osteoma	0.5	0.4	0	-	-	-	-	-	-	-	-	-
Femoral Supracondylar Process	0.2	0	0.8	1.1	-	-	-	-	-	-	-	-
Femoral Anteversion	1.5	2.6	1.5	-	-	-	-	-	-	-	-	-
Allen's Fossa	2.3	2.6	2.3	21.7	-	-	-	-	-	-	-	-
Poirier's Facet	0.5	6.4	3.1	-	0	0	0	0	7.1	-	-	-
Plaque Formation	4.3	30.2	37.7	36.6	-	-	-	-	-	-	-	-
Hypertrochanteric Fossa	16.1	16.6	10.8	-	-	-	-	-	-	-	-	-
Third Trochanter	17.8	3.8	4.6	-	14.2	30.4	27.7	36.4	40	-	-	-
Vastus Notch	5.1	1.1	1.5	51.6	-	-	-	-	-	-	-	-
Tibia Anteversion	0.5	0	0.8	-	-	-	-	-	-	-	-	-
Tibia Osteoma	0.2	0.4	1.5	-	-	-	-	-	-	-	-	-
Squatting Facet	28.9	12.8	17.7	-	-	-	-	-	-	-	-	-
Inferior Talus Single Articular Facet	42.9	29.8	50.8	-	-	-	-	-	-	-	-	-
Inferior Talus Double Articular Facet	20.4	34.0	52.3	-	-	-	-	-	-	-	-	-
Single Calcaneal Articular Facet	43.5	16.2	6.2	3.7	-	-	-	-	-	-	-	-
Double Calcaneal Articular Facet	21.4	0.4	0	53.5	-	-	-	-	-	-	-	-
Peroneal Tubercle	12.6	0	0.8	-	-	-	-	-	-	-	-	-
Metatarsal Osteoma	0	0.4	1.5	-	-	-	-	-	-	-	-	-

POU=Poulton Chapel, SOC=St. Owen's Church, NP=Norton Priory, WP=Wharram Percy, HIR=Hirsel, MK=Monkwearmouth, JA=Jarrow, BG=Blackgate, BF=Blackfriars, SB=St. Brides (SB), SPC=Spitalfields, TC=Terry Collection

Table 39 and 40 identifies the percentage differences between the comparative samples. Sexes are combined, and non-adults have not been included. There are some notable percentage differences encountered for some NMTs. The samples used in this thesis reported a higher percentage of metopism in comparison to the other samples. The bregma ossicle presented a very low percentage for all samples. The coronal ossicle identified a mixed percentage across all samples with the highest percentage of 12% for the Spitalfields Collection. The parietal foramen, mastoid foramen, lambdoid ossicle and asterion ossicle was remarkably low in the Poulton Chapel, St. Owen's Church and Norton Priory Collections when compared to the comparative samples. Most postcranial NMTs presented similar frequency percentages between all samples. However, some NMTs were notably higher in percentage in comparison. For example, the allen's fossa, acetabular crease and the vastus notch almost double in percentage frequency.

The final aim of this thesis includes the use of NMTs to identify plausible familial relationships within the Poulton Chapel, St. Owen's Church and Norton Priory Collections. It is believed that individuals who are likely closely related genetically tend to be buried near one another. Also, individuals sharing similar traits are thought to be more closely related than those sharing fewer traits. The subsequent chapter will explore this notion through two approaches: 1) hierarchical cluster analysis is used to identify sub-groups of individuals bearing similar combinations of NMTs and 2) burial spatial analysis which utilises the location of each individual within the burial ground, permitting the analysis of distribution patterns between various NMTs.

Chapter 6 Results Part 3

Identifying Possible Familial Relationships within a Cemetery Context

One of the aims of this thesis is to identify possible familial relationships within the Poulton Chapel, St. Owen's Church and Norton Priory Collections. Mortuary customs have changed and developed throughout the centuries covering a wide range of burial practices (e.g. cremations with ashes placed in pots and then buried, supine burials buried east-west orientation, the use of burials goods and so on…). However, one thought must really be considered throughout this review, and that is that the dead do not bury themselves. For all burials, the treatment of an individual's death and burial is the result of the survivor(s). As reported by Pearson (1993) "their treatment of the deceased is conditioned by their perception of death and their relationships with each other". This study is a review of the physical remains of the deceased with an aim to reveal information about the life of an individual and not about their death. However, there is a vast amount of archaeological research summarising funerary practices that reveal more about what the living perform for their dead (e.g.: Agarwal and Glencross, 2011; Murphy, 2008; Knudson and Stojanowski, 2008; Chapman *et al.,* 1981; Humphreys and King, 1981; and Roberts *et al.,* 1989). This information is fascinating, but it reveals more about the living than the dead themselves (Pearson, 2011). In some instances, the deceased will request specific arrangements in advance of burial (Daniell, 1998). For example, historical records (e.g. wills) can record such details and, at Poulton Chapel, the will of Sir Nicholas Manley revealed such a request:

"*I Nicholas Manely whole of body and perfect of mind, intending to avoid discord after my death, make my will. My body to be buried in the chapel of Pultoh in the Chancel…"*

Sir Nicholas Manely died in 1519, and his will is one of a few surviving documents that relate to the Manely family and led to speculation that perhaps his grave might still be intact within the chancel area of Poulton Chapel (Emery, 2000). However, local folklore suggests that several burials were disturbed during the beginning of the 20th century (Emery, 2000). Unfortunately, at this point, the Harris Matrix is incomplete for this archaeological site with few AMS radiocarbon dating analyses. In turn, the identification of his burial and grave location is still currently under investigation.

Regardless, this type of information can provide valuable information into burial practices at that point in time for a specific burial ground.

The analysis of intra-population organisation can provide further information on the relationship between the living and dead. Such comparisons explore the contrasts between basic concepts such as household and grave, the organisation of burials by sex, kin, status, or for some contexts, cosmological principles. Or, burials which may affect the social order (e.g. deviants such as witches and executed criminals) who threatened the symbolism of the central social values were buried elsewhere (Pearson, 1993). Despite various complicating factors, NMTs traits have provided some support in the assessment of bio-distance in ancient populations (Tyrell, 2000). Kinship studies have been the interest of many anthropologists to aid the interpretation of social organisations within and between ancient societies (Pilloud and Larsen, 2011). This interest has led to the analysis of various population groups and social structures through the use of dental, cranial and postcranial NMTs (Turner and Scott 1977; Strouhal and Jungwirth, 1979; Bondioli *et al*., 1986; Spence, 1996; Adachi *et al.,* 2003; Irish, 2005; and Velemínský and Dobisíková, 2005). These studies consider various burial contexts (e.g. isolated double burials, small burial groups, large cemeteries with distinctly grouped areas) in order to determine plausible familial relationships. It is believed that individuals who are likely closely related genetically tend to be buried near one another. Also, individuals sharing similar traits are thought to be more closely related than those sharing fewer traits. Such heritability has been verified on Howells' cranial dimensions (Howells, 1973; Sjøvold, 1984) and among monozygotic and dizgotic twins in recent populations (Townsend *et al.,* 2015). Genetic determination through NMTs is complicated due to the unknown number of genes that code NMTs and their variability (Velemínský and Dobisíková, 2005), this is further influenced by sex, geographic origin and further factors caused by the poor preservation of archaeological remains. However, various studies have suggested that skeletal NMTs are at least partially heritable (Berry and Berry, 1967). Although some dental NMTs have been included in NMT research, dental NMTs are now represented as an independent group of traits. According to more recent research, they have a much stronger genetic component to skeletal NMTs (Turner *et al.,* 1991; Scott and Turner, 1997; Alt, 1997; Alt and Vach. 1998; Irish, 2005).

Although there are many issues surrounding the use of NMTs as an indicator of familial lineages, they can be reviewed for archaeological skeletons with verified genealogical data. Although such collections are rare, there are some exceptions within the UK and Europe. For example, a Portuguese skeletal collection held at the University of Coimbra (Bocquet-Appel, 1984), the Austrian Hallstatt Collection (Sjovold, 1984, 1986) and collections from Luxemburg and Habsburg (Vlcˇek, 1987, 1997). Further studies in Europe include royal families from Hungary (Rösing, 1986a, b) and Assuan in Egypt (Rösing, 1990). These studies, alongside the use of metrical traits and blood groups, were able to verify a degree of kinship. In London, UK, there are the Named Spitalfields Coffin Plate Collection (Molleson and Cox, 1993) and the St. Bride's Collection (Scheuer and Bowman, 1995) could be used to determine which NMTs correlate with biological kinship. However, only a few relationships could be summarised through the use of NMTs. For the samples included in this thesis (Poulton Chapel, St. Owen's Church and Norton Priory Collections) obtaining funds to attempt aDNA analyses on these individuals (n=997) is unlikely for such a large sample.

This chapter will explore possible familial relationships through the use of two approaches: 1) hierarchical cluster analysis and 2) burial spatial analysis, both permitting the analysis of distribution patterns for the 126 NMTs recorded for this research. From this, consideration of specific individuals sharing similar NMTs could be considered for aDNA research in the future (see Chapter 7).

6.1 Hierarchical Cluster Analysis

For this section, the distance of dissimilarity between the observed data of 126 NMTs will be explored using a dendrogram, or tree, where the 126 NMTs are joined together in a hierarchical fashion from the closest, that is most similar, to the furthest apart, that is the most different. It is assumed that individuals sharing similar combinations of NMTs are more likely to be closely related than those who share fewer combinations. A hierarchical clustering dendrogram (based on average linkage within groups and a squared Euclidean distance dissimilarity coefficient) builds the hierarchy from individual elements by progressively merging clusters. However, for these analyses, the data of all 126 NMTs is required for each individual. As this data is recorded on a present (1) and absent (0) basis, it is not possible to estimate the missing values (9). Here, only individuals for whom 126 skeletal variants could be scored as '1' and '0' could be included. This resulted in a subsample from the Poulton Chapel (n=148), St Owen's Church (n=31) and the Norton Priory (n=61) Collections.

6.1.1 The Poulton Chapel Collection

The results of the cluster analysis (based on average linkage within groups) for Poulton Chapel can be seen in Figure 29. This dendrogram is very compact in comparison to the dendrogram of St. Owen's Church and Norton Priory. Here, numerous clusters between groups of individuals sharing similar trait combinations can be seen. However, the results of this cluster analysis appear to offer no evidence that these individuals who share similar trait combinations, were interred near one another in the Poulton Chapel burial ground. A possible reason for this lack of spatial clustering could be due its long period of use. It is believed that the large burial ground at Poulton Chapel was in use for approximately 400 years (see Chapter 2). This, with the lack of permanent grave markers, could lead to the 'newly' dead were buried amongst earlier burials whose locations and identities had been forgotten. Unfortunately, only a few individuals have been subjected to AMS radiocarbon dating analysis and these individuals are not included in this hierarchical cluster analysis due to incomplete NMT data. Alongside this, the Harris Matrix of the archaeology at Poulton Chapel is incomplete and remains to be verified. This, in turn, means that further distinctions of these clusters cannot be explored by phases of the Chapel's usage. Exploration of these burial spatial distributions can be seen in section 6.2. However, it is possible that most individuals buried at Poulton Chapel are likely to be fairly closely related genetically anyway. This factor could support the lack of burial spatial clusters of individuals with similar NMT combinations being evident archaeologically.

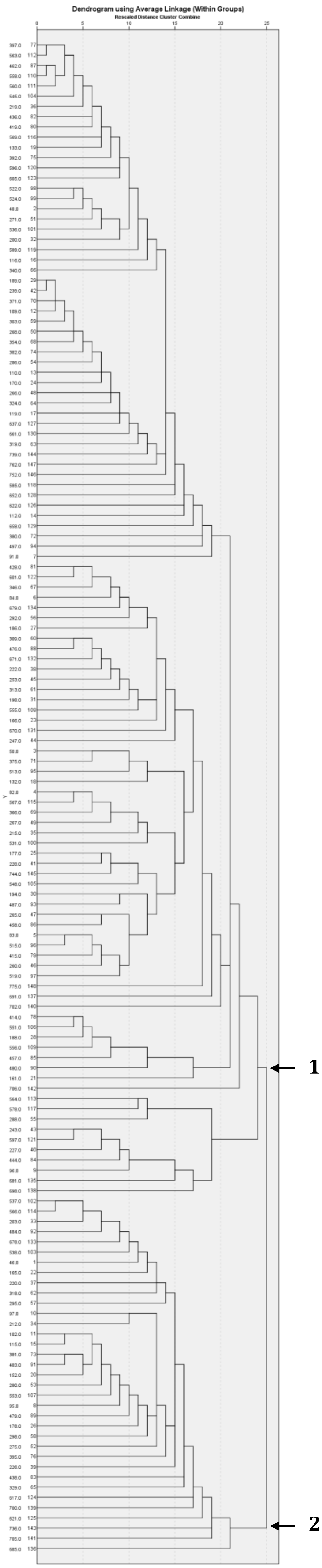

Figure 29: Hierarchical cluster analysis (within groups) of Poulton Chapel (n=148)

6.1.2 The St. Owen's Church Collection

The results of the cluster analysis (based on average linkage within groups) for St. Owen's Church can be seen in Figure 30. The dendrogram of this cluster analysis identifies the clustering of 31 individuals with similar NMT combinations. Here, three distinct groupings can be identified. As previously identified in Chapter 2, the archival information of the burials for the individuals buried at St. Owen's Church is currently unavailable. Unfortunately, this means that the burial location of the individuals included in this hierarchical cluster analysis is unknown. Furthermore, no individuals from this collection have been subjected to AMS radiocarbon dating. Like Poulton Chapel, burials were interred at St. Owen's Church for approximately 400 years (see Chapter 2) although the number of burials is far less in comparison (St Owen's Church; n=296 and Poulton Chapel; n=726). The author can speculate that is it plausible that familial relationships can be observed from this dendrogram due to the reasonable sample size subjected to this analysis (n=31). However, until the archival information becomes available, this interpretation will remain unresolved.

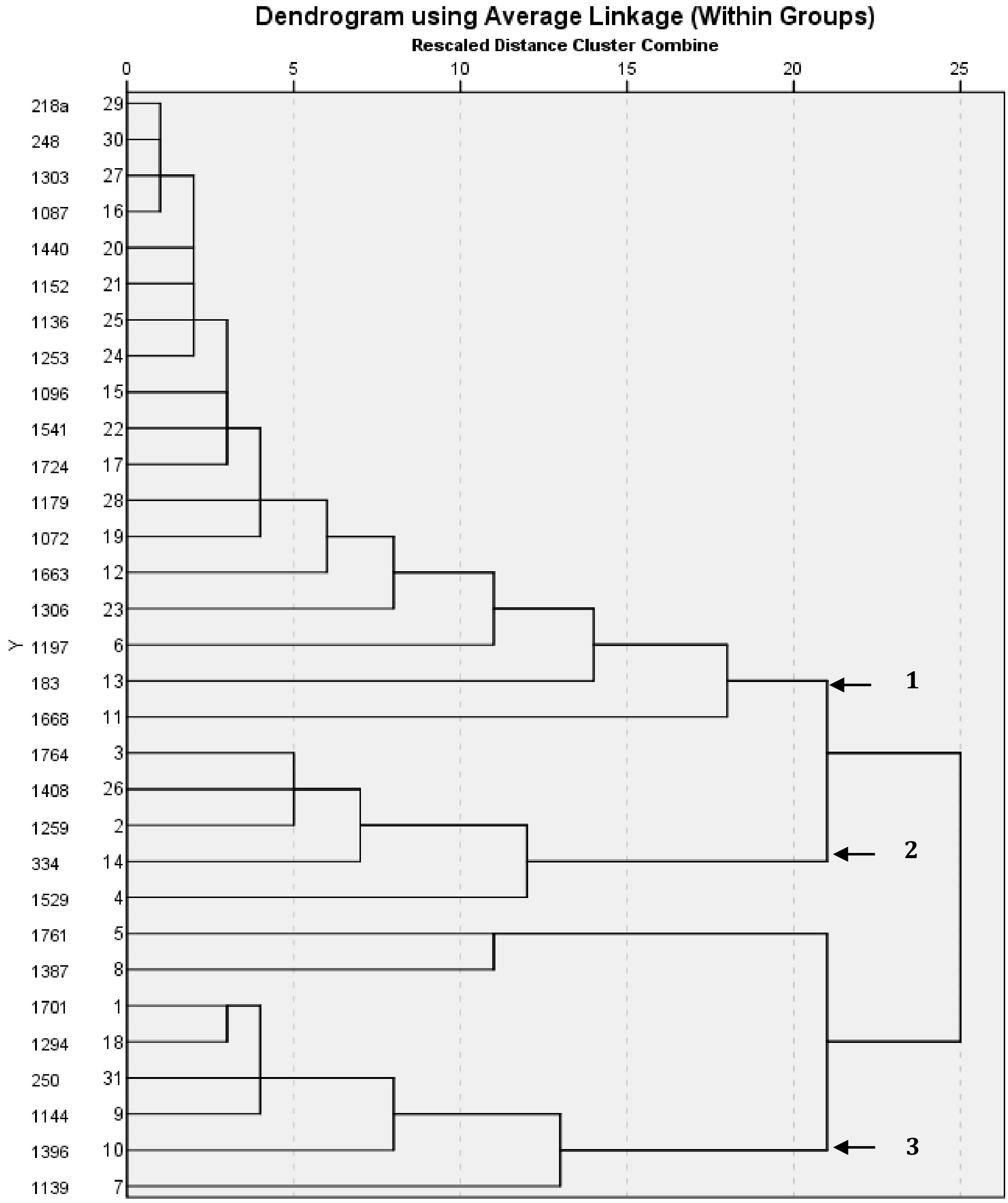

Figure 30: Hierarchical cluster analysis (within groups) of St. Owen's Church (n=31)

6.1.3 The Norton Priory Collection

The results of the cluster analysis (based on average linkage within groups) for Norton Priory can be seen in Figure 31. This dendrogram is the most interesting of the three sample sites included in this hierarchical cluster analysis. Here, two distinct clusters of individuals sharing similar NMTs can be observed with one cluster split further into two smaller clusters. Further exploration of the burial locations for the individuals in the clusters (n=61) suggests plausible evidence of family burial areas within the priory.

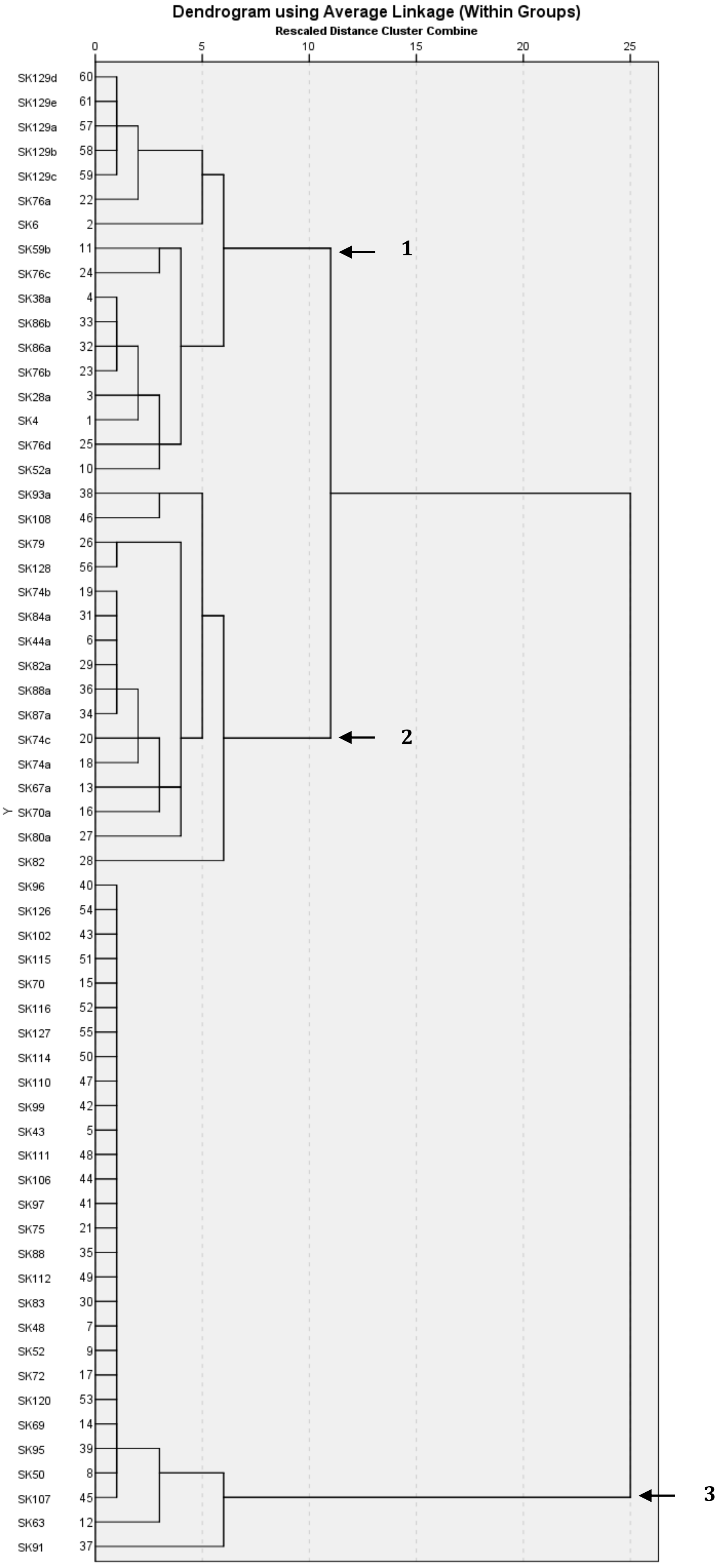

Figure 31: Hierarchical cluster analysis (within groups) of Norton Priory (n=61)

As previously mentioned in Chapter 2, it has been strongly supported that specific areas of the burial ground at Norton Priory were associated with individual groups (e.g. families and canons) and this dendrogram seems to support this notion. Here, the individuals of the second or lowest cluster (3) consist of those buried within the north-east Chapel. This place of burial is associated with one of the Priory's benefactor families, the Dutton family (Brown and Howard-Davis, 2008). This hierarchical cluster analysis highlights both male and female burials sharing similar combinations of NMTs. However, it must be noted that burials from other areas of the Priory, including the Nave and extended Nave, also share similar combinations of NMTs.

The first or top cluster of individuals is divided further into two groups. Here, although there is some overlap, there is an interesting divide in the associated place of burial. The first cluster (1) is primarily associated with burials from the Chancel and Nave while the second cluster (2) are mostly burials from the south-east chapel. It is believed that the Chancel was reserved for another benefactor family of the Priory while the Nave, although not restricted to a particular family, were individuals of high status. It must be noted that most individuals buried at Norton Priory are likely those of high status, as indicated by their ornately designed stone coffins. However, the association of individuals buried within the Nave and those of the Chancel sharing similar combinations of NMTs could still be related genetically. The individuals buried in the Nave may have had more influence in the Priory. Finally, the second cluster (2) are from the south-east Chapel, another area of the Priory dedicated to a particular family.

Overall, the results of this hierarchical cluster analysis are truly interesting. Three groups of individuals have been identified as sharing similar combinations of NMTs. This is further supported by their place of burial as each cluster of individual's falls to a single place of rest at Norton Priory and, through historical literature, have been identified as designated areas of burial for particular family groups. Unfortunately, none of the individuals included in this analysis has been subjected to AMS radiocarbon dating. However, some selected individuals are subject to review for a separate project exploring aDNA for this collection. With much anticipation, confirmation of the relationship between these burials may/may not confirm the likelihood of family lineages at Norton Priory.

6.2 Burial Spatial Distribution

This analysis was only conducted for the Poulton Chapel, and Norton Priory Collections as no archival information is currently available for the St. Owen's Church during the investigation of this thesis. Although only two samples are being subjected to burial spatial analysis, the results should prove to be interesting. Poulton Chapel is a large cemetery with numerous burials taking place over 400 years likely comprising of families from several generations. Norton Priory is a little different. Burials have been taking place here for a similar period of time and through historical records have identified that certain areas of this burial ground have been designated to particular families.

6.2.1 The Poulton Chapel Collection

For the Poulton Chapel analysis, the burial ground presented here is still under excavation and presents a large cemetery with no distinct grouping between the burials. For example, there is no distinct grouping between the non-adults and adults, or by sex (see Figure 6) although previous acknowledgements suggest that there is a high number of non-adult burials to the south-west corner of the cemetery (Burrell *et al.,* 2012; 2013). However, as the site is still under excavation, this notion is liable to change. Nonetheless, this type of burial ground could provide interesting clusters of possible familial groups through the identification of rare anomalies that are predominately site-specific (Stojanowski and Schillaci, 2006). This is opposed to small grave analyses where common skeletal variants have performed well in kinship reconstructions (e.g. Adachi *et al*., 2003; Adachi *et al*., 2006; and Boljunčić, 2007). However, the application of such rare traits in large burial contexts as a proxy for familial relationships is limited to when these rare traits can occur, as they can occur either by chance or through manifestation within a particular lineage. Here, individual NMTs will be used as a proxy for establishing spatial distributions within the burial ground of Poulton Chapel as an aid to identify plausible familial relationships. Appreciatively, the location of each individual has been previously recorded during the excavation process. Here, the north and eastern coordinates recorded from the crania will be used to identify the location of each burial from this sample. Unfortunately, of the 602 individuals, 26 cannot be subjected to spatial analysis due to missing location data. Nonetheless, the remaining 576 individuals were subjected to spatial distribution analysis using ArcGIS. Incorporated within these distribution maps is the surrounding archaeology, inclusive of the two phases of the Chapel and the overlaying 5m grid system (see Figure 6).

Within this large cemetery, the burials will be reviewed for general spatial distributions to identify any possible subgrouping between the traits observed, indicating favoured areas within the burial ground for family groups. The results of the hierarchal cluster analysis for this site has identified numerous clusters of individuals sharing similar combinations of NMTs. Although a summary review has been provided (see 6.1), attempts to review this further will be made in this section. Further focus will be applied to the unusual and simultaneous burials. All burials will be highlighted as either a non-adult or adult and/or by sex. It must be noted that the location data of these burials essentially creates a 2D representation model of the Poulton Chapel burial ground. Even though the surrounding archaeology has been incorporated into the distribution maps, interpretations of the burials located within the walls of the Chapel must be made with caution. At this point, the Harris Matrix of the archaeology from Poulton Chapel is yet to be verified so distinctions between the burials within and outside the walls of the Chapel for social segregations cannot be attempted here.

6.2.1.1 Hierarchal Cluster Analysis

This has been reviewed in the previous section (see 6.1). For the Poulton Chapel Collection, numerous clusters of individuals sharing similar combinations of NMTs has been identified. However, the results of this cluster analysis appear to offer no evidence that these individuals who share similar trait combinations, were interred near one another in the Poulton Chapel burial ground (Figure 32). This distribution map highlights all 526 individuals with an identified burial location. However, only those included in the hierarchal cluster analysis (Cluster 1 and 2) are distinguished here. These analyses were re-run for the divided clusters. However, the results were inconclusive and produced no evidence for spatial groupings (data not shown). There are numerous reasons for the lack of success with this model. Firstly, this burial ground was in use for roughly 400 years, and there is a lack of permanent grave markers for the individuals buried here. This probably leads to the burial of *new* individuals in areas of forgotten families and/or individuals. It is also possible that most individuals buried at Poulton Chapel are likely to be closely related genetically anyway. Although few, these factors could support the lack of burial spatial clusters of individuals with similar NMT combinations being evident archaeologically.

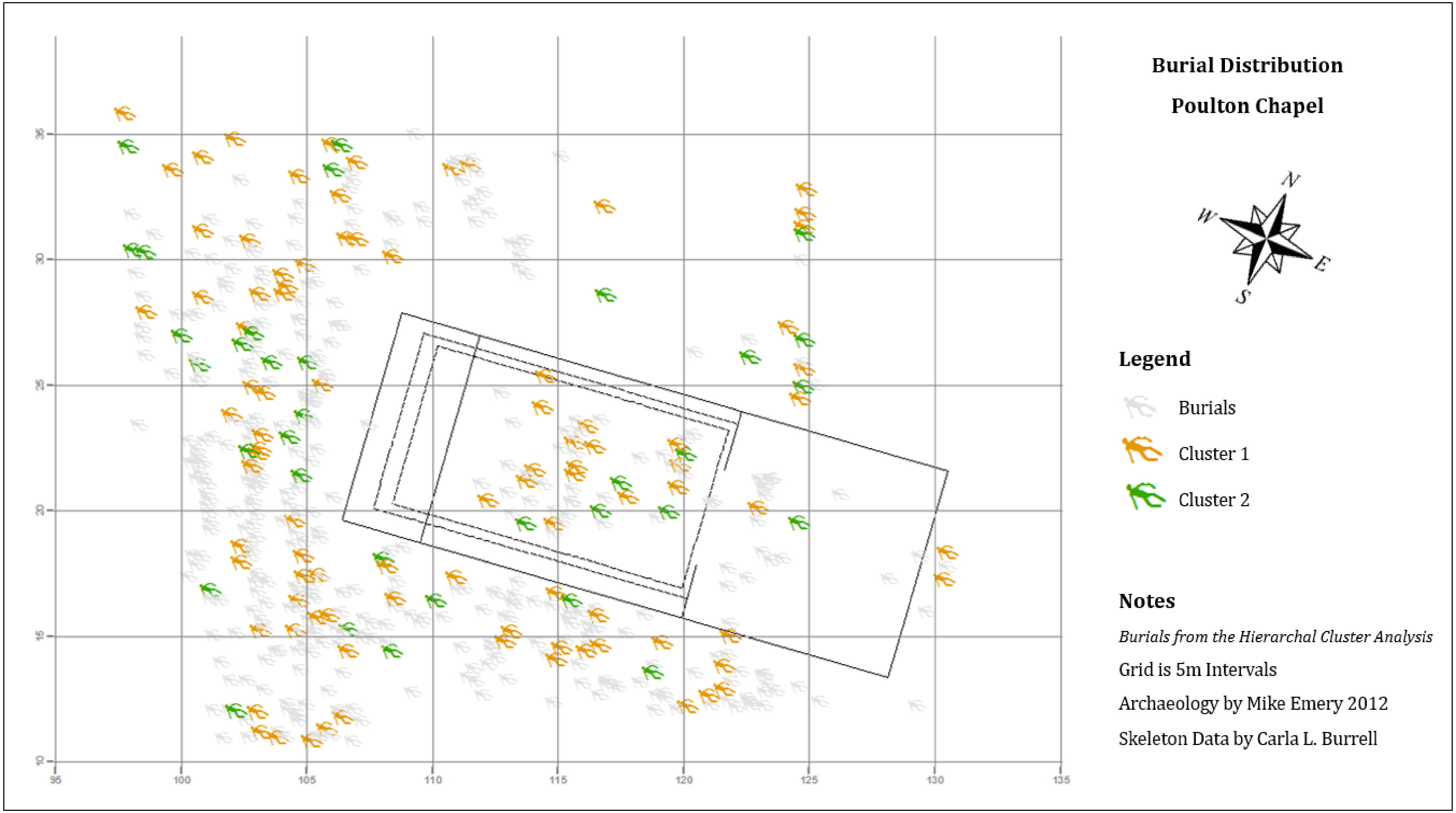

Figure 32: Burial distribution of the hierarchical cluster analysis for Poulton Chapel

6.2.1.2 Cranial Nonmetric Traits of Genetic Influence

Here, only a few NMTs of the cranium that are believed to be of genetic influence have been selected for burial spatial analysis. Firstly, metopism was subjected to review as this is a commonly recorded NMT for most archaeological skeletal collections. At this point, the burial distribution of those individuals with a patent metopic suture (metopism) shows little difference between areas of the burial ground (see Appendix 9). Individuals with metopism are spaced across the cemetery, mostly to the south and western sides of the Chapel. However, this probably due to the incomplete excavations to the north and eastern parts of the Chapel. It must be noted that a few individuals do appear to be buried within close proximity to each other. For example, there are two non-adults on the southern side of the Chapel (12N, 106E) and a male and female to the south-west corner of the Chapel (17N, 105E).

Concentrating on the burial distribution of individuals with an ossicle at lambda, burials were dotted across the burial ground. Although, there seem to be groups of burials focused towards the north-west and to the south-west side of the Chapel (see Appendix 10). There does appear to be a male and female (18N, 108E) who are buried close to one another near the southern wall of the Chapel. Continuing with sutural variants, individuals with a lambdoid ossicle were subjected to spatial analysis. Many more individuals present this NMT because of this any distinct clustering is less apparent (see Appendix 11). However, there are numerous small clusters of two or three individuals buried next to one another across the cemetery.

6.2.1.3 Dental Nonmetric Traits of Genetic Influence

Within the Poulton Chapel sample, four dental variants that are considered rare were selected for spatial burial analysis. Dental anomalies are often reported in archaeological collections, and such anomalies have revealed patterns of association with genetic disorders highlighting a genetic origin for these conditions (Witkop, 1976). However, it must be highlighted that the recording of dental anomalies requires extensive knowledge of the dentition. This study recorded only a few dental NMTs. Further data and research are required to understand the true intra-population variation of the dentition. Here, 11 individuals (1.8% of the sample) presented a variation of a peg tooth with a higher occurrence in females (n=7, 63.6%) than males (n=3, 27.3%). Only one non-adult exhibited a peg tooth. The majority of these variations presented the peg tooth as a replacement for the 3rd molar, with a higher occurrence on the right side (71.4%). Four individuals presented a peg-shaped lateral maxillary incisor, two of which occurred on the right side, one to the left. Interestingly, an adult female exhibited peg-shaped lateral maxillary incisors to both sides. When these individuals were subjected to burial spatial analysis, no distinguished clusters are apparent. However, there is a higher frequency of burials to the north side of the Chapel (see Appendix 12). This is particularly interesting as the excavations to this part of the cemetery are currently incomplete.

Sixteen individuals presented shovel-shaped incisors within this collection (2% of the sample). Twelve were exhibited by non-adults (75%), the remaining consisted of two males and two females. The adults are distributed to the south side of the chapel while the majority of the non-adults are presented across the north-west area of the Chapel (see Appendix 13). Relatedly, only three individuals presented congenital absence of dentition, an adult male and female and a non-adult (0.5% of the sample). Each presented congenital absence of both lateral maxillary incisors. Interestingly, the female had a replacement peg tooth to the left side. Finally, only two cases of talan cusp were recorded within the Poulton Chapel Collection (0.3% of the sample), and both were presented on the left side of the maxilla. This adult female and non-adult were subjected to burial spatial analysis. The non-adult lies inside the walls of the Chapel while the female lays on the southern side of the Chapel (see Appendix 14).

6.2.1.4 Postcranial Nonmetric Traits of Genetic Influence

For the Poulton Chapel sample, some postcranial traits that are considered unusual were applied to the spatial analysis. As a whole, postcranial variants have not been subjected to such detailed study as those of the crania. However, some variants have received attention for different reasons (Benfer and McKern, 1966; Finnegan, 1978; and Brothwell, 1981). Numerous postcranial skeletal variants have been included in this study but, only a handful of those is considered unusual (Stojanowski and Schillaci, 2006) was reviewed for spatial analysis. Here, individuals with an accessory sacral facet were subjected to burial spatial analysis. There appears to a concentration of burials on the southern side of the Chapel (see Appendix 15). This trait is only exhibited within the adult sample, and there is a slight focus of female burials to the western side of the Chapel.

Here, nine adults (1.5% of the sample) exhibited a subscapular foramen. These NMTs were more frequent within females (n=7, 77.8%) than the males. No bilateral occurrence of this trait occurred; five females presented a subscapular foramen on the left side and two for the right side. The males only exhibited this trait on the right side. The majority of these burials are located on the south side of the Chapel (see Appendix 16) but, two lie on the north side of the Chapel. Interestingly, a male and female are within close proximity to one another within the nave of the Chapel.

Five individuals presented a humeral supracondylar process within this collection (0.8% of the sample), two females (40%), two males and a non-adult. A female presented bilateral asymmetry of the humeral supracondylar process, while the other presented it only on the left side. However, the males and non-adult exhibited this NMT unilaterally. When subjected to burial spatial analysis no clusters were apparent (see Appendix 17).

Eleven individuals presented femoral anteversion within this collection (1.8% of the sample), seven females (63.6%), three males (27.3%) and one non-adult. The non-adult presented bilateral asymmetry of this skeletal variant. For the males, two presented unilateral occurrences, and one had bilateral occurrence. Finally, one female exhibit bilateral occurrence while the remaining six present unilateral occurrences (left n=4, and right, n=2). When subjected to spatial analysis, no distinct cluster was apparent. However, two pairs of adults (a male and female and, two females) are buried quite close to one another along the south-east side of the Chapel (see Appendix 18). Relatedly, three individuals exhibited tibia anteversion (0.5% of the sample), one male, one female and one non-adult. Interestingly, all three individuals presented bilateral occurrence of this skeletal variant, and when applied to spatial analysis, all burials are located along the south side of the Chapel.

6.2.1.5 Vertebral Nonmetric Traits of Genetic Influence

Fascinatingly, the Poulton Chapel Collection is interesting regarding the vast number of vertebral anomalies in comparison to the two other sample sites. Extra or missing vertebral segments usually occur from an abnormal number of somites during development rather than from border shifts (McCollum *et al*., 2010). These anomalies usually occur in the thoracolumbar or lumbosacral regions during foetal development (Barnes, 1994). Here, 22 individuals (3.7% of the sample) exhibited an extra vertebral segment and were subjected to spatial analysis (see Figure 33). Two adult males presented an extra thoracic vertebra with articulating 13th ribs whereas the remaining 20 individuals (eight non-adults, eight males and four females) exhibited an extra lumbar vertebra. Here, there is a higher prevalence of extra vertebral segments in males (45.4%) than females (18.2%), which is similar to other populations (e.g. Allbrook, 1955; Bornstein and Peterson, 1966; and Stewart, 1972). However, no single cluster has been presented, but four possible clusters do appear within the burial ground.

The extra vertebral segments were not the only vertebral variants recorded within the Poulton Chapel Collection. Here, various border shifts (e.g. Cervicothoracic shift, Lumbosacral shift caudal and cranial) were recorded. One adult male exhibited a caudal shift within the occipitocervical cranial border. Although this type of border shift is the first within the Poulton Chapel Collection, it is not uncommon and has been reported in other populations (Barnes, 1994; Masnicova and Beňuš, 2003; and Müller and O'Rahilly, 2003). Two non-adults presented a thoracolumbar border caudal shift (Merbs, 1974; Barnes, 1994; and, Cimen and Elden, 1999). Two individuals exhibited a caudal shift of the lumbosacral border: an adult female presented unilateral articulation of the 5th lumbar vertebra and a non-adult presented with an incomplete bilateral articulation of the 5th lumbar vertebrae. This is a frequent anomaly often reported in other population groups (Barnes, 1994; Carrott *et al*., 2004; and Cottage and Wilton, 2011). Similarly, five individuals who exhibited an extra lumbar segment presented a caudal shift of the lumbosacral region. These included an adult male and two non-adults with incomplete bilateral articulation of the 6th lumbar vertebrae, one non-adult exhibits unilateral articulation of the 6th lumbar vertebrae and finally, the last non-adult presents complete articulation of the sixth lumbar segment. One case of congenital absence of the 12th thoracic vertebral segment occurred for an adult female. Eighteen individuals present an example of block vertebra (2.9 % of the sample), 11 are segmentation failures of the cervical vertebra (2nd and 3rd cervical n=8; and 6th and 7th cervical n=3) and seven are segmentation failure of the lower thoracic vertebra (7th and 8th thoracic n=2; 8th and 9th thoracic n=2; 9th and 10th thoracic n=2; and 10th and 11th thoracic n=11), fifteen of these individuals are males (83.3%) while the rest are females (16.7%). Similar cases have been reported in other collections (Leivseth *et al*., 2005; and, Silva and Ferreira, 2008).

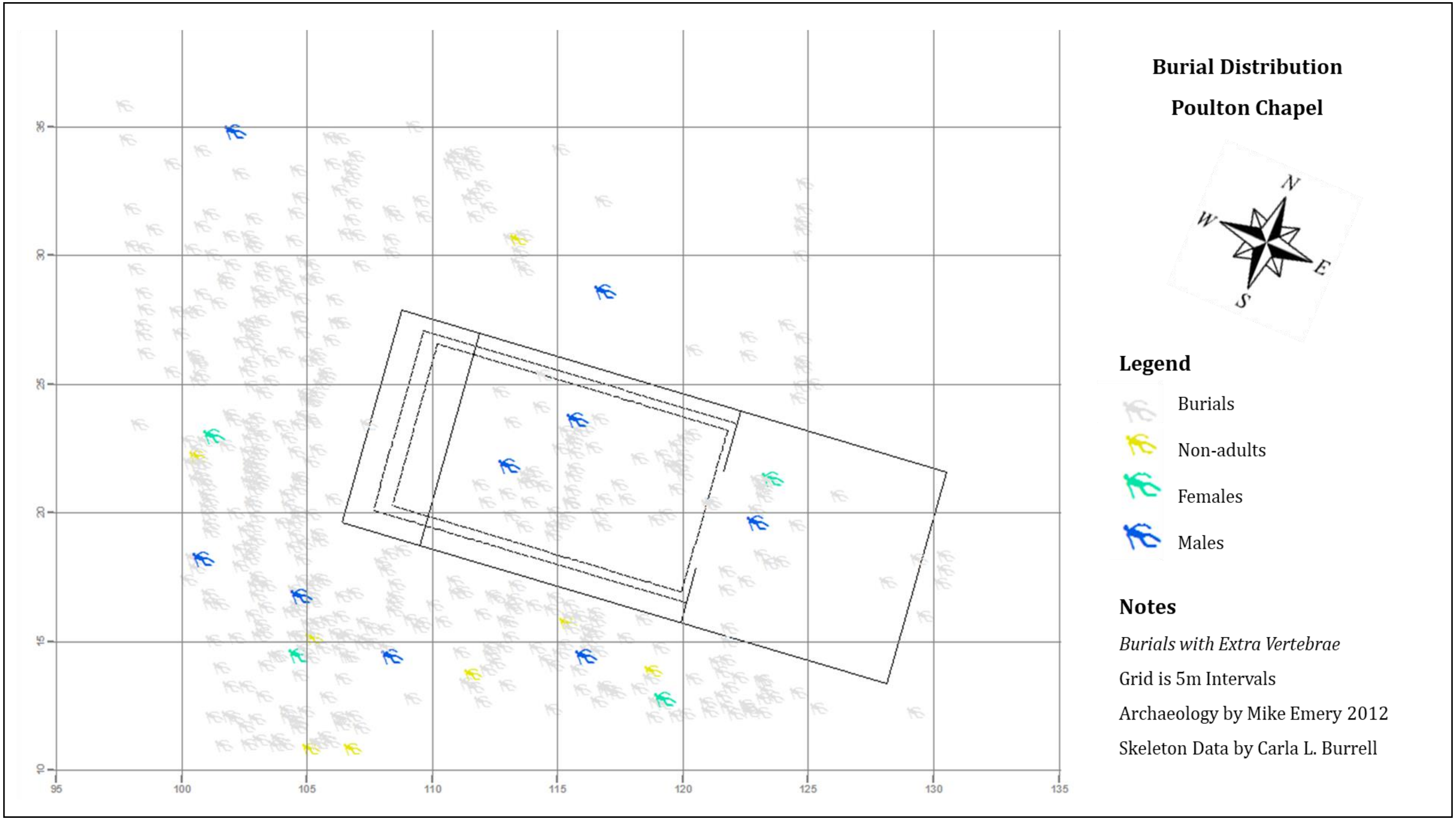

Figure 33: Burial distribution map of individuals with an extra vertebra at Poulton Chapel

There are variations in the developmental delay of the neural arches (e.g. bifid and cleft neural arch, Spondylolysis of the neural arch and spina bifida). Bifurcation of the neural arch occurs for 2.4% of this sample, 60% of these are non-adults, and 33.3% are males. Clefting occurs for 3% of this sample with almost an even split between non-adults and by sex. Spondylolysis of the neural arch occurs within 1.8% of the population, with a higher frequency for the females (54.5%) than the males (27.3%) and the non-adults (18.2%). Spina bifida occulta occurs within 5.3% of the population, with a slightly higher frequency with for the males (40.6%) than females (37.5%) and non-adults (21.9%). As there is such a high frequency of vertebral variants within the Poulton Chapel Collection, these variants were subjected to spatial distribution analysis. However, no clusters were apparent.

6.2.1.6 Reversed Burials

Within the Poulton Chapel Collection, nearly all burials were buried in an east-west orientation (head facing east) which is typical of Christian burials (Daniell, 1998). However, three burials are in an easterly direction (SK142, SK286 and SK571) and are randomly distributed within the burial ground at Poulton (see Appendix 19). SK142 is a non-adult who exhibits an ossicle at lambda and a unilateral humeral aperture. SK286 is an adult male, and SK571 is an adult female, both share the occurrence of the parietal foramen, an occipital bun and a third trochanter. No NMTs are shared with the non-adult. Although unusual, reversed burials have been reported at other archaeological sites (Daniell, 1998). Daniell (1998) lists numerous explanations including simple carelessness, difficulties in identifying the orientation of the body wrapped in a shroud, head to toe packing of multiple burials in a restricted space and, the possibility of deliberate ill-treatment of the dead, especially for individuals considered as criminals. Unfortunately, there is no evidence to support or rebut any of these hypotheses for the Poulton Chapel individuals. Another possibility for the reversed adult burial is that it is that of a priest. Who would be expected to rise facing his flock on the day of resurrection. However, Daniell (1998) states that this is a post-medieval custom and Medieval burials assumed to be priests are buried the same way as everyone else. With this information and, alongside the burial positioning of these adult individuals, it can be suggested that these burials are not those of a priest.

6.2.1.7 Simultaneous Burials

There is a fascination with family burials, and images of a simultaneous burial of several individuals within a single grave are often interpreted to imply a familial relationship, especially within an archaeological context (Cohen, 2015; and Stojanowski and Duncan, 2015). Such assumptions can be justified in some cases with the support of aDNA analysis (e.g. Velemínský and Dobisíková, 2005). It is often assumed that a double burial could be husband and wife, mother and child, or even an important individual and follower (Paul and Stojanowski, 2015; and Stojanowski and Schillaci, 2006). It is essential to clarify the relationship between the individuals who share their grave as it is possible that they had a strong familial relationship or not. Supporting this notion are the various kinship studies that have been attempted on known and unknown populations with particular focus on small family tombs, isolated double burials and small burial groups (Adachi *et al.,* 2003; Velemínský and Dobisíková, 2005; Adachi *et al*., 2006; and Boljunčić, 2007) with some success.

Further care must be made for married individuals. The chances for husband and wife passing at the same time is unlikely. However, if an unfortunate event was to occur, the possibility of them sharing similar NMTs will be unlikely. Typically, husband and wife would be from two separate families who would marry for a set purpose, usually for political reasons (Daniell, 1998). This presents two different combinations of NMTs. In turn, their children are likely to share a mixed combination of both parents. Unfortunately, with simultaneous burials, the diversity of possible combinations of individuals buried within a single grave complicates the chance of a solution without aDNA. The possibility of two family members passing away at the same time is unlikely but, it is not impossible. On the other hand, especially for groups of children contained within a single burial, they could have been affected by the same disease and perished at a similar time. Although, they may not have been siblings they could be close friends within close family groups. Families may have buried their children together, sharing their time in grief. Alongside this, burying their children together in the one large grave maybe easier to prepare then preparing a single grave for each child. It may also have reduced the costs of burial.

At Poulton Chapel, nine simultaneous burials have been identified during the excavations. These burials have been identified as simultaneous due to various factors including the closeness of two or more individuals, skeletal elements are touching/resting on one another, and they share a single grave cut. The aim here is to explore the NMTs recorded for each individual within each of the nine simultaneous burials, identifying if any NMTs are shared between the individuals of the same grave. This analysis could indicate familial relationships between the individuals of each burial group. At this point, there is no spatial distribution apparent between these multiple burials across the Poulton Chapel site (data not shown).

- *Triple Burials***.** Of the nine contemporary burials, four presented the interment of three individuals occurring from a single deposition. Group 1 (Figure 34A) consists of three non-adult burials (SK441, SK451 and SK452). SK441 presents metopism and multiple lambdoid ossicles. SK451 exhibits a bifurcation of the C1 anterior neural arch and presents an extra lumbar vertebra. No NMTs are shared between these burials. Group 2 comprises of two adults, one male and female, and a non-adult (SK520, SK521 and SK522). SK520 has a humeral septal aperture, and SK521 has a suprascapular foramen both individuals have parietal foramina. SK522 exhibits a partial metopic suture, supraorbital notches and squatting facet's but shares no traits with the other individuals. Group 3 is comprised of two adult females and a non-adult (SK523, SK524 and SK525). SK523 presents a partial metopic suture, supraorbital notch and clefting of C1 neural arch whereas SK524 exhibits supraorbital foramen and parietal foramen. No traits are apparent for the non-adult or shared between the females. Finally, Group 4 (Figure 34B) consists of three non-adults (SK645, SK646 and SK650). SK645 presents a supraorbital foramen. SK646 exhibits metopism and supernumerary sutural ossicles whereas SK650 also presents multiple lambdoid ossicles and a vastus notch.

Figure 34: Group 1 (A) and Group 4 (B). Image courtesy of Alan Wilmshurst

- *Double Burials.* The remaining five contemporary burials present the interment of two individuals within a single deposition. Group 5 is comprised of two non-adult burials (SK183 and SK184). No skeletal variants are apparent for SK183. However, SK184 presents a caudal shift of the thoracolumbar border. Group 6 is an adult female (SK467) and non-adult (SK468) burial. SK467 exhibits a partial metopic suture and supraorbital foramen. However, no traits are present for the non-adult burial. Group 7 (Figure 35A) is that of an adult male (SK537) and non-adult (SK556). SK556 exhibits lambdoid ossicles. However, both individuals present partial metopic sutures and supraorbital notches. Group 8 is the only contemporary burial containing two adult males (SK559 and SK639). SK639 presents a partial metopic suture, parietal foramen, asterion ossicle and peroneal tubercles. However, both individuals exhibit supraorbital foramen, lambdoid ossicles and hypertrochanteric fossa's. The last group, Group 9 (see Figure 35B) consists of a young male adult (SK691) and adolescent (SK692). SK691 exhibits an auditory torus, humeral supracondylar process and third trochanters, while SK692 has metopism and partial spina bifida occulta. SK691 and SK692 both present an occipital bun and lambdoid ossicles. However, they are presented unilaterally and opposite to one another.

Figure 35: Group 7 (A) and Group 9 (B). Image courtesy of Alan Wilmshurst

6.2.2 The Norton Priory Collection

In comparison to Poulton Chapel, the excavations at Norton Priory are complete, and the analysis of the spatial burial distribution can be incorporated alongside the vastly excavated Priory ruins. As a monastic site, the total number of males overcomes the number of females and non-adult burials. However, through various historical information, it has been identified that specific areas of this Priory have been designated to individual families. Alongside this, the level of intercutting between burials is scarce in comparison to the heavily used site at Poulton Chapel. Here, at Norton Priory, each individual buried here has their designated place of burial, and the wealth and importance behind these individuals can be speculated on by their ornate stone coffins and/or beautifully decorated stone coffin lids. These structures are meant to survive for extended periods of time permitting future generations to know where to visit and see their final resting place is. This, in turn, permits *living* family members to choose their place of burial without disturbing their past relatives. Due to this burial practice, it may be possible to identify possible clusters of family groups within specific areas of the Priory. Here, individual NMTs will be used to establish spatial distributions within the burial ground of Norton Priory as an aid to identify plausible familial relationships. The location of each burial is known due to the thorough recording completed during the original excavations. However, the north and eastern coordinates are not available. With careful consideration, the location of each burial was plotted using a geo-reference tool within the ArcGIS software system. This incorporated the location of each burial on top of a copy of the excavation plans of the Priory (see Chapter 2). There are 130 individuals recovered during the original excavations. However, six individuals cannot be subjected to spatial analysis as their approximate burial location is unknown. Nonetheless, the remaining 124 individuals were subjected to spatial distribution analysis using ArcGIS here for the first time.

Within this cemetery, the burials will be reviewed for general spatial distributions to identify any possible subgrouping between the NMTs recorded, indicating favoured areas within the burial ground for family groups. The results of the hierarchal cluster analysis for this site has identified clusters of individuals sharing similar combinations of NMTs. A summary review has been already being provided (see 6.1), but a visual interpretation of these results will be provided here. All burials will be highlighted as either a non-adult or adult and/or by sex. It must be noted that the location data of these burials essentially creates a 2D representation model of the Norton Priory burial ground. The surrounding archaeology has been incorporated into the distribution maps (see Figure 14).

6.2.2.1 Hierarchal Cluster Analysis

This analysis has been reviewed in the previous section (see 6.1). At Norton Priory three groups of individuals have been identified as sharing similar combinations of NMTs. This was explored further to identify the approximate burial location of the individuals from each cluster group, and the results were promising. Each cluster of burials appears to favour a specific area within the Norton Priory ruins, and with supporting historic information, it is known that these areas have been previously designated to individual family groups. The results of the hierarchal cluster analysis were subjected to burial spatial distribution analysis (Figure 36). Figure 36 highlights the burial position of all 124 burials. However, only those individuals included in the hierarchal cluster analysis are distinguished here (n=61). The burials from Cluster 1 appear to be focused towards the western part of the Priory specifically the north Aisle and Nave. Majority of the burials identified in Cluster 2 are buried within the Nave and south-east Chapel's. Interestingly, two individuals are buried very close to one another within the south-east Chapel. Finally, Cluster 3 is the largest collection of individuals from the hierarchal cluster analysis. At a glance, these burials do appear to be scattered across the Priory ruins. However, there is a large number of burials within the north-east Chapel's and Nave. The results of these spatial analyses are very interesting as the north-east Chapels were built after the great fire of 1236. From historical sources, it is known that these extensions were built for the Dutton family who made many endowments to the Priory during this time (Brown and Howard-Davis, 2008). This high concentration of individuals sharing similar combinations of NMTs and the supporting historic documentary information suggests that these individuals are probably related. However, the author does realise that aDNA analysis is required to confirm these results.

6.2.2.2 Cranial Nonmetric Traits of Genetic Influence

This research records 55 NMTs from the crania, and only a few that are considered genetic in origin were subjected to burial spatial analysis. Alongside this, some NMTs considered as ambiguous were subjected for review. The first NMT subjected to spatial burial distribution was metopism as this NMT is frequently recorded for most archaeological collections. For the Norton Priory collection, 30 individuals are recorded with a metopic suture (one non-adult, five females and 29 males) almost 23% of the sample. When subjecting these individuals to the burial spatial analysis, no clusters were apparent. In fact, the burials are spread out across the burial ground (see Figure 37).

A commonly reported supernumerary suture ossicle includes the ossicle at lambda. This NMT has been observed in 14 individuals from the Norton Priory Collection (10.8% of the sample). When subjected to burial spatial analysis, the burials are located across the ruins. However, there appear to be two possible groups of burials. Firstly, there are two females buried within the north-east Chapel and three males buried towards the western end of the Nave (see Figure 38). Further research is being considered to review the size and shape of this NMT to see if any additional details can be identified (see Chapter 8).

Alongside these distributions, the frontal osteoma and sagittal bun were subjected to spatial burial distribution. These NMTs are not considered genetic in origin but as ambiguous due to their cause of occurrence is unknown. A frontal osteoma was observed within six individuals (4.6% of the sample). Unfortunately, only five were subjected to burial spatial analysis with three of these individuals located within the Nave (see Appendix 20). Finally, individuals with a sagittal bun were subjected to burial spatial analysis and two are located within the east Cloister walk (see Appendix 21). This finding is interesting, especially as the individuals buried within the Cloister walk are considered cannons of Norton Priory.

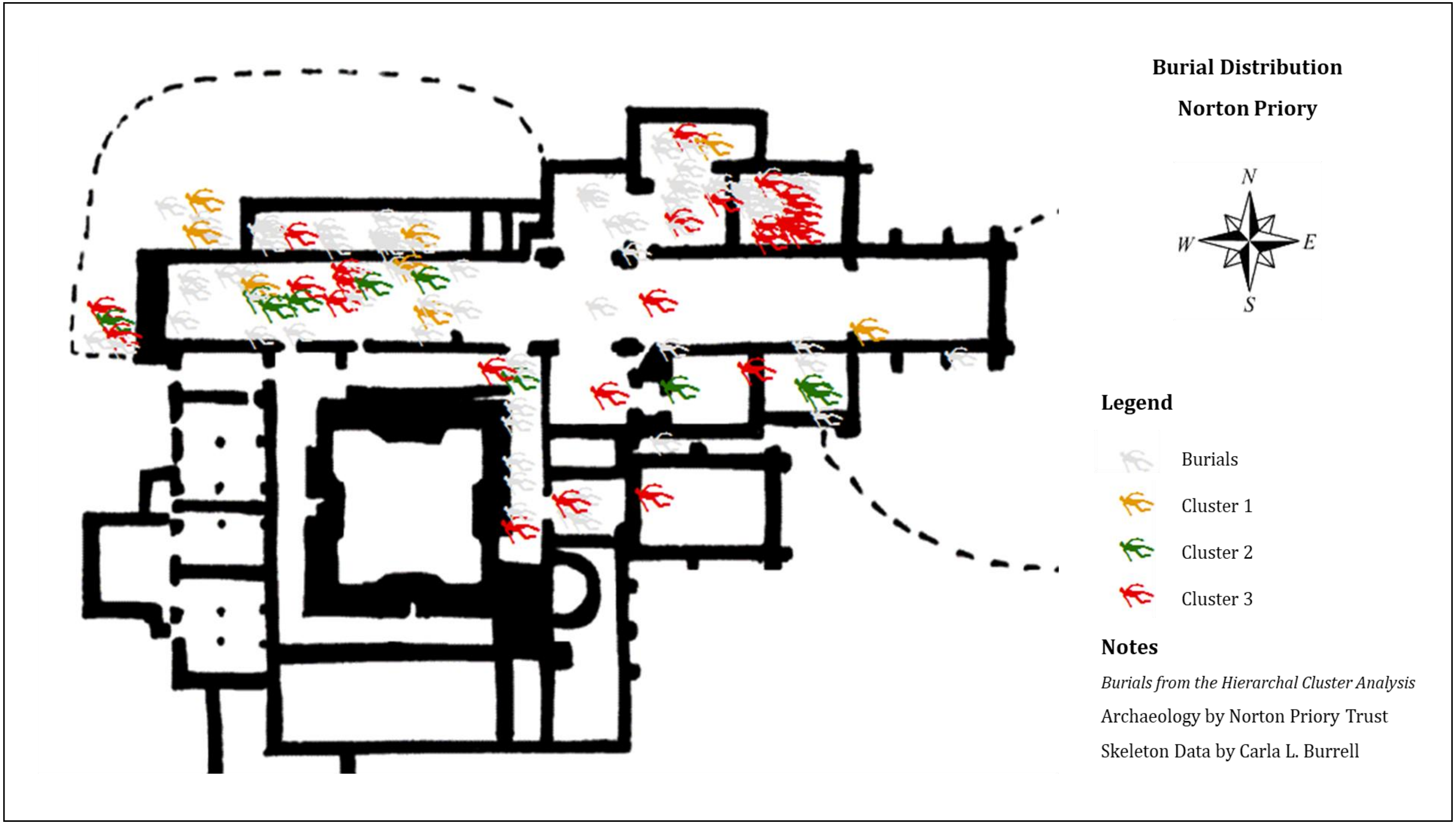

Figure 36: Burial distribution of the hierarchical cluster analysis for Norton Priory

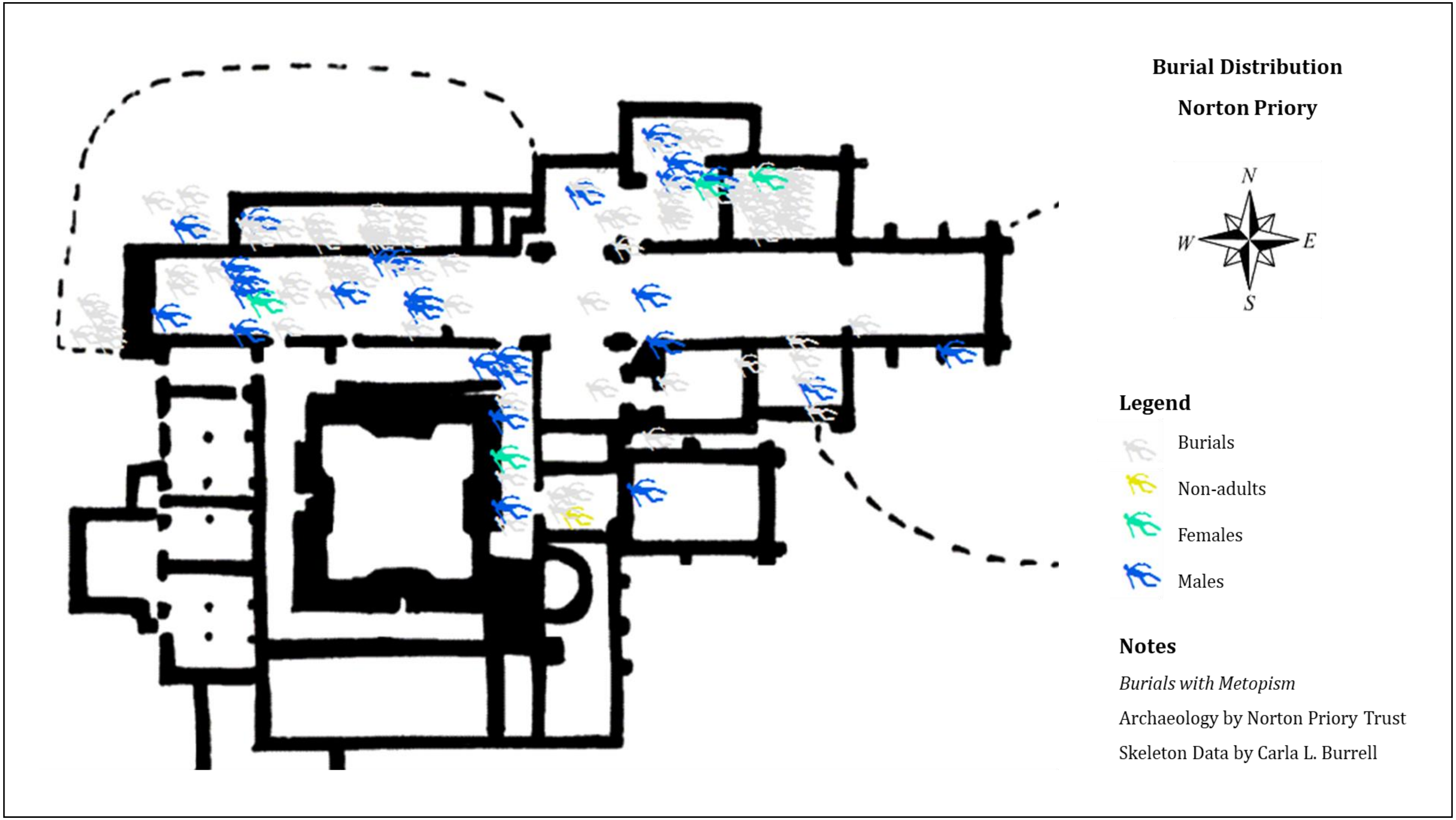

Figure 37: Burial distribution map of Norton Priory: Metopism

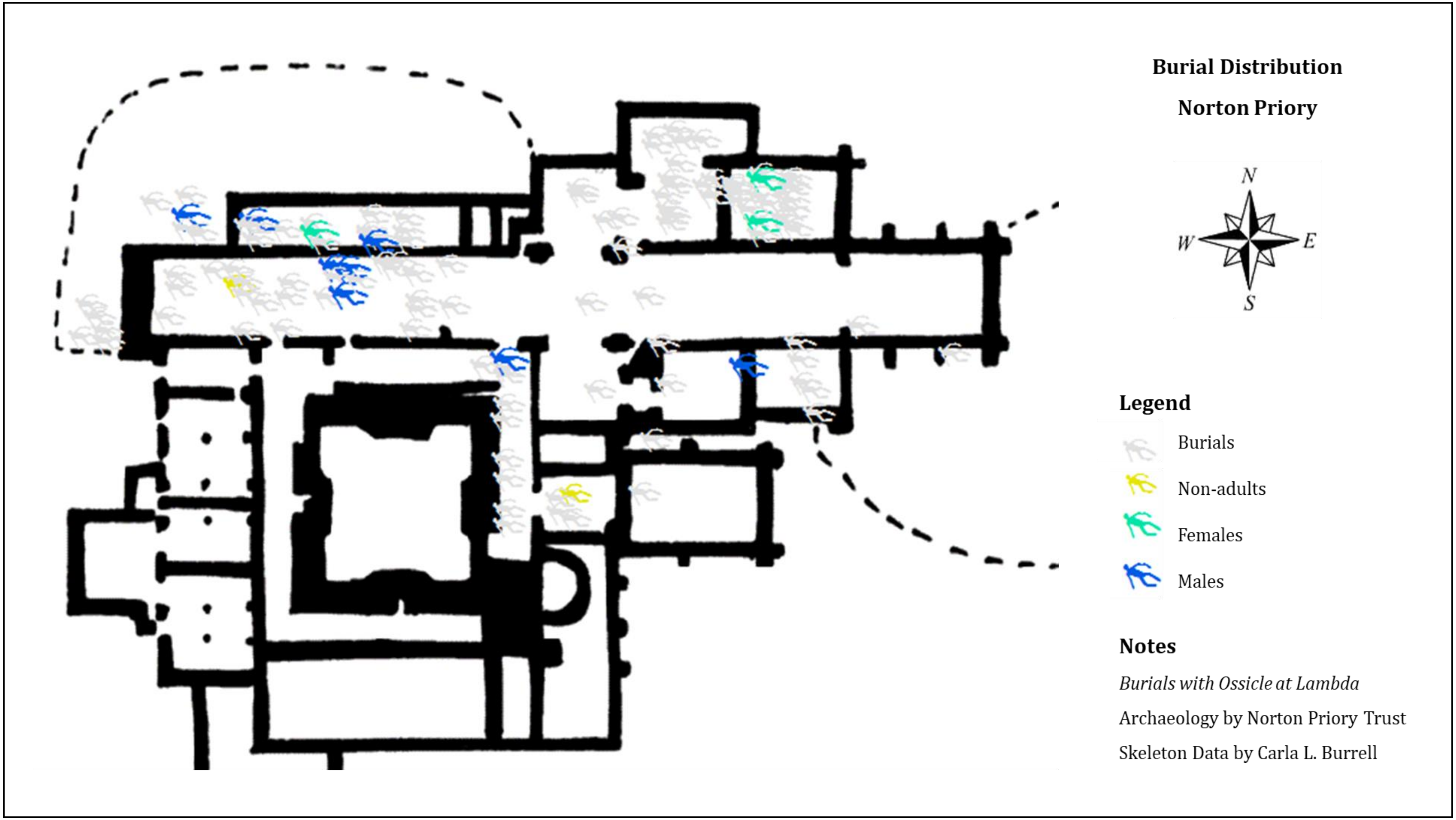

Figure 38: Burial distribution map of Norton Priory:

6.2.2.3 Dental Nonmetric Traits of Genetic Influence

Only a few dental NMTs were observed within the Norton Priory Collection. However, the mandibular torus was a frequently recorded NMT within this collection and in turn, was subjected to burial spatial analysis. Here, nine individuals (7% of the sample) exhibited this trait, and these burials appear to be scattered across the burial ground. However, there are four individuals buried within the Nave, two of whom are buried alongside one another (see Appendix 22).

6.2.2.4 Postcranial Nonmetric Traits of Genetic Influence

For the Norton Priory sample, some postcranial NMTs that were considered unusual were subjected to burial spatial analysis. As previously acknowledged, the exploration of postcranial NMTs has not been extensively reviewed in comparison to NMTs from the crania. Some NMTs were subjected to burial spatial analysis but showed little clustering within the burial ground. However, the tibia osteoma was reported in four individuals (3% of this sample). When subjected to burial spatial analysis, these individuals were scattered across the Priory ruins with no apparent clusters (see Appendix 23). Another postcranial subjected to this analysis included the peroneal tubercle. This is a small facet located on the lateral side of the calcaneus and is associated with activity-related causes. For the Norton Priory Collection, nine individuals presented this NMT (7% of the sample). Interestingly, three of these individuals (all male) are located within the east Cloister walk. This area of burial is considered the resting place of the Norton Priory Cannons. Alongside this, we have a male and female buried close to one another within the north-east Chapel too (see Figure 39).

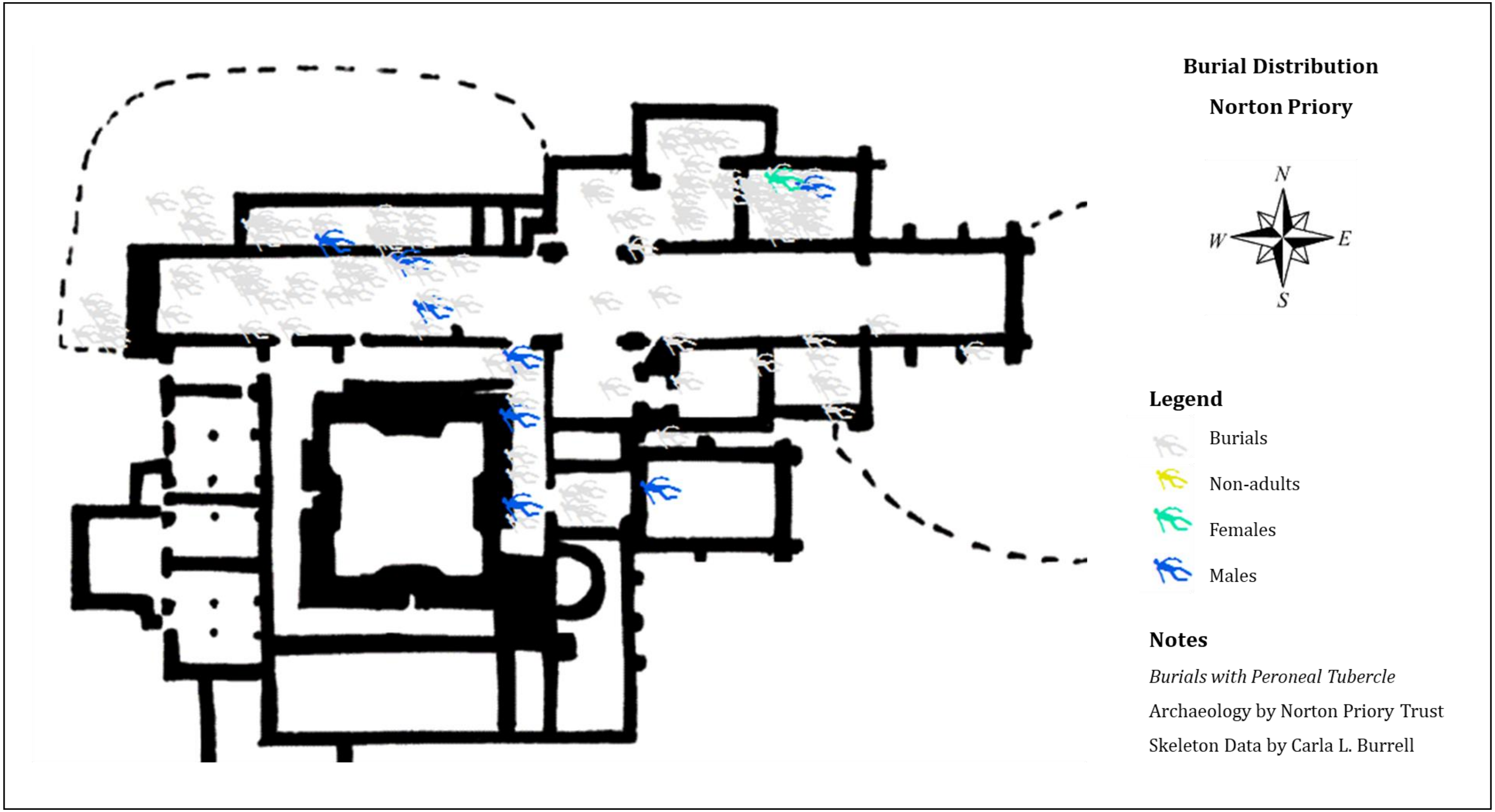

Figure 39: Burial distribution map of Norton Priory: Peroneal Tubercle

6.2.2.5 Vertebral Nonmetric Traits of Genetic Influence

Only a few NMTs of the vertebral column were recorded within the Norton Priory Collection. Only three individuals (2.3% of the sample) exhibited an extra lumbar vertebra. Two of these individuals, a male and female, are located in the north-east Chapel. The third individual is buried towards the western part of the Nave (see Figure 40). Alongside this, there were cases of a vertebral border shift specifically in the lumbosacral area or lumbarisation of S1*.* Here, six individuals (4.6 of the sample) displayed a border shift of this region. Two males and a non-adult are buried within the Nave of the Priory, while the other three adults are located across other areas of the Priory (see Figure 41). This is quite interesting as it could be possible that the three individuals buried within the Nave are of same family lineage.

6.3 Reflection of Probable Familial Relationships

This Chapter aimed to explore the possibility of identifying familial relationships within a cemetery context of the Medieval Poulton Chapel, St. Owen's Church and Norton Priory Collections using hierarchical cluster and burial spatial analysis. These methods intended to explore the 126 NMTs recorded in this thesis as a means to determine relationships as it is believed that individuals who are likely closely related genetically tend to be buried near one another. Also, individuals sharing similar traits are thought to be more closely related than those sharing fewer traits. The results of these analyses provided some insight into the use of NMTs in distinguishing possible familial relationships.

Firstly, all 126 NMTs were subjected to hierarchical cluster analysis for the Poulton Chapel (n=148), St. Owen's Church (n=31) and Norton Priory (n=61) Collections. This method identifies the distance of dissimilarity between the observed data of 126 NMTs using a dendrogram and the results for each collection varied dramatically. Firstly, the results from the Poulton Chapel Collection were unsuccessful. This dendrogram (see Figure 29) identified numerous clusters, but no spatial burial patterns were observed within the burial ground. This lack of clustering could be due to the extensive and long use the burial ground at Poulton Chapel. This, with the lack of permanent grave markers, could lead to the 'newly' dead being buried amongst earlier burials whose locations and identities have since been forgotten. It is possible that most individuals buried at Poulton Chapel are likely to be closely related genetically anyway as it is quite a secluded village.

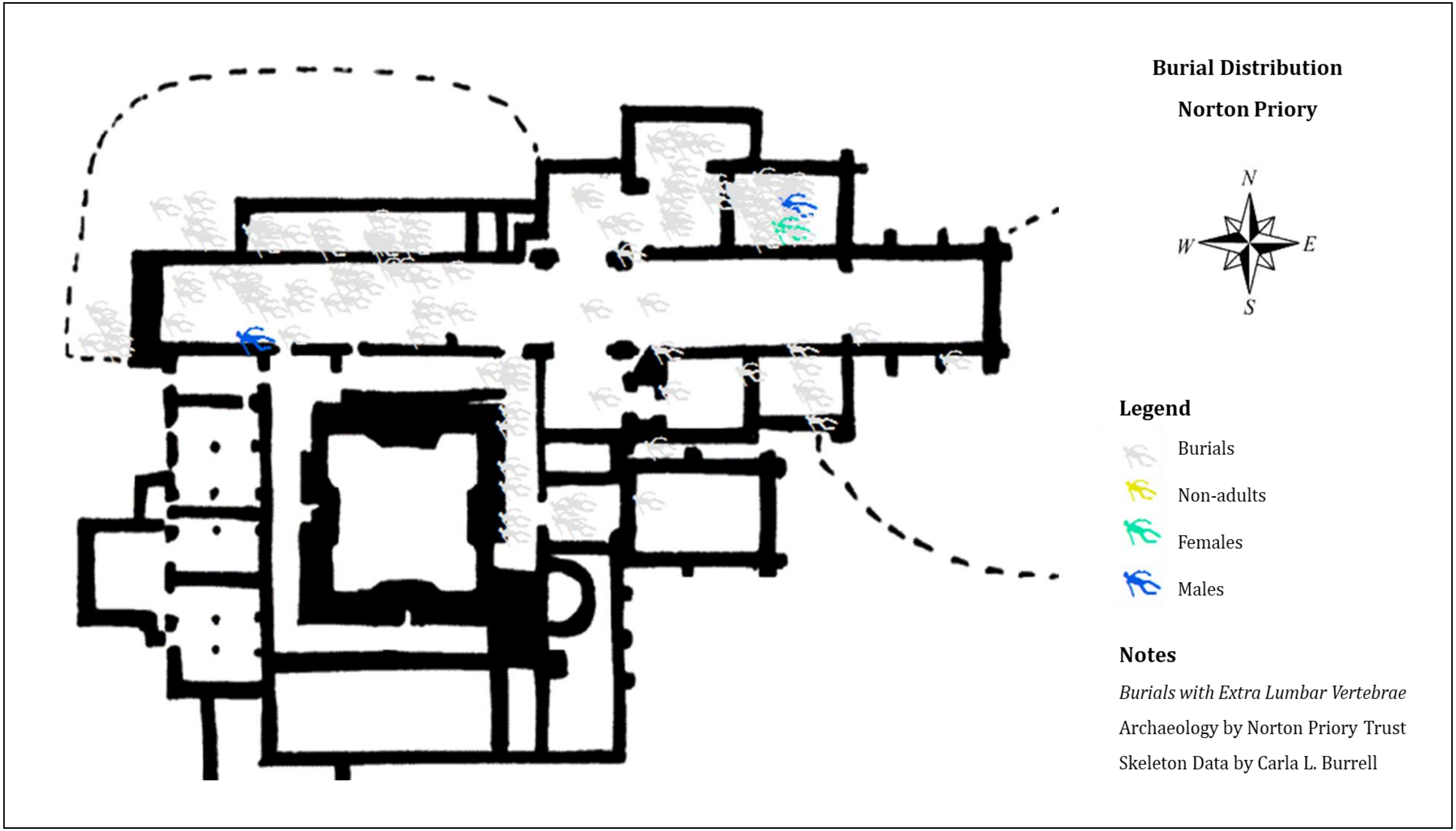

Figure 40: Burial distribution map of Norton Priory: Extra Lumbar Vertebrae

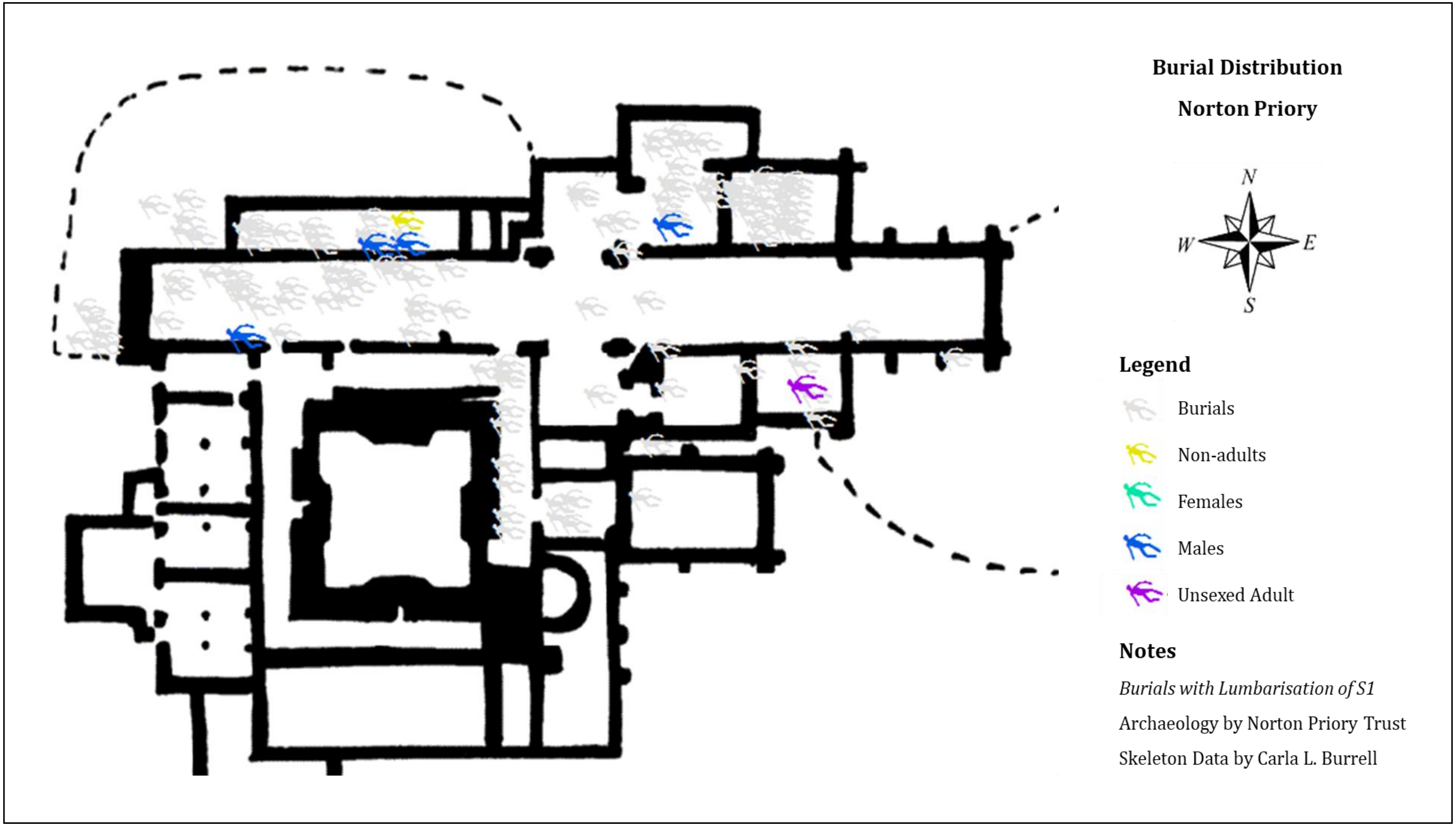

Figure 41: Burial distribution map of Norton Priory: Lumbarisation of S1

The results for the St. Owen's Church sample provided some possible clustering between individuals sharing similar combinations of the 126 recorded NMTs. It can be speculated that plausible familial relationships can be observed from this dendrogram due to the reasonable sample size subjected to this analysis (n=31). However, until further archival information is available surrounding the location of the burials for this collection, the application of this information is currently on hold. The most interesting and supporting results of possible familial relationships using NMTs were reported from the Norton Priory Collection. Three clusters of individuals sharing similar combinations of NMTs were identified and, when subjected to burial spatial analysis, these results provided specific areas of burial within this cemetery (see Figure 31 and 36). With supporting historical literature, these areas have been identified as designated areas of burial for particular family groups supporting the possible familial relationships likely identified from these combinations of 126 NMTs.

Alongside this, NMTs from the Poulton Chapel and Norton Priory Collections were subjected to burial spatial analysis using ArcGIS. This method was applied to determine any possible clusters of individual NMTs that could indicate possible familial relationships within the cemetery of Poulton Chapel and Norton Priory. As previously noted, only 576 individuals from Poulton Chapel and 124 individuals from the Norton Priory Collection were subjected to this analysis. This is due to lack of burial location information available. Positively, this does provide a large sample from each collection to be included in this analysis. All burials are considered Christian in origin with all interments buried an east/west alignment (Daniell, 1998).

For the Poulton Chapel Collection, very little clustering was apparent within the burial ground. However, in some instances, some burials were found adjacent among males and females, females and children, some males are close to other males, and neighbouring children. Speculatively, males and females could be husband and wives buried together, mothers with their children, males buried close to other males could be related through sons, brothers or even as cousins and, clustering of non-adult burials could be those of siblings. Interestingly, the majority of the clustering is found along the south and western sides of the Chapel with a re-occurring cluster to the north-eastern part of the cemetery. There are numerous reasons for this occurrence; 1) this could be a favoured area of burial, 2) there could be social segregation within the community or 3) these clusters could be occurring simply by chance as excavations are incomplete for this site. Interestingly, there is a high number of vertebral anomalies within the Poulton Chapel Collection, and these may provide a valuable step in identifying plausible relationships. The high occurrence of genetic depositions to the axial skeleton is exceptional within this collection. Barnes (1994) notes similarities in patterns of some congenital defects that follow within kinships lines, highlighting a genetic origin. It is possible that this is the case within the Poulton Chapel Collection although aDNA is required to prove this reasoning. The high occurrence seen at Poulton Chapel has not been reported within other archaeological collections (Mays, 2006; and Roberts and Manchester, 2010). Based on historical sources, the structure of the local landscape suggests that Poulton is a nucleated village where many holdings gathered around a small green near a Chapel (Emery, 2000). Interestingly, this is similar to the Modern Poulton. Today, the village of Poulton consists of a small community of approximately 90 people. However, during the Medieval period, Morgan (1978, pp265a,b) suggests that there were only approximately 30 villagers here at any one time. It is likely that the Medieval community of Poulton was quite segregated from neighbouring communities, permitting the possibility of interbreeding between close family groups, leading to this high occurrence of genetic vertebral anomalies.

For the Norton Priory Collection, little clustering was apparent for most NMTs within the burial ground. However, some NMTs provided some interesting clusters and were focused towards areas known to be linked to specific family groups. Like the Poulton Chapel Collection, to confirm these clusters of individuals as possible family members, aDNA is required. Even though having this data and historical records for the Norton Priory Collection it will be valuable to have these additional analyses to confirm these notions. Unlike Poulton Chapel, the individuals buried at Norton priory have their designated place of burial, and the burials have quite elaborate stone coffin burials, so they are not forgotten in death. This prevents any intercutting of burials and over use of a specific area of the burial ground. This means that individuals chose their place of burial, which would typically be with their family members, next to their husband and wife, next to their parents and so on.

This chapter has demonstrated the results of the intra-population hierarchal cluster and burial spatial analysis, although interesting, are inconclusive for the Poulton Chapel and St. Owen's Church Collection while the results for the Norton Priory Collection are promising. However, the high occurrence of genetically rare traits of the vertebral column found at Poulton Chapel could provide a valuable step in revealing some familial relationships for this sample. Currently, these burial spatial distribution analyses focus solely on single traits whereas mapping multiple traits could be far more effective. Further and future approaches such as applying statistical analysis to identify distance rates between burials, or the consideration of aDNA should be integrated alongside these analyses to determine familial relationships for all three collections. Chapter 7 discusses the results of the Poulton Chapel, St. Owen's Church and the Norton Priory Collections. Identifying the limitations of this study, highlighted intra- and inter-population differences and pinpointing the strengths and future ambitions of this project in aid to develop these analyses as a proxy for determining familial relationships within a cemetery context.

Chapter 7 Discussion

Objectives, Findings and Recommendations

This study has led to the assessment of 1,187 individuals from the Medieval Poulton Chapel, St. Owen's Church and Norton Priory Collections. However, only 997 individuals were subjected to statistical analysis. This thesis proposed several objectives; 1) to establish the demographics and 2) document the frequency of 126 NMTs for each sample. 3) Establish if age or 4) sex affect the expression of the recorded 126 NMTs, 5) to explore possible familial relationships using hierarchal and burial spatial analysis and finally, 6) identify if activity-related NMTs differ in expression between rural and urban populations and, if possible, by social segregation. Overall, this research aimed to provide insight into possible familial relationships within the Medieval communities of Poulton Chapel, St. Owen's Church and Norton Priory using 126 NMTs. All objectives have been addressed, and the main findings have been interpreted and evaluated below. Alongside this, avenues considered for further and future research are identified in this chapter.

7.1 Intra-Populational Review

The first aim of this thesis was to attain a full, detailed account of the demographics of the Poulton Chapel, St. Owen's Church and Norton Priory Collections. For each individual, full inventories and determinations of age-at-death, sex and stature have been established when possible (Chapter 4). Poulton Chapel and St. Owen's Church presented an even distribution between the ratio of non-adults to adults, and then by sex. In contrast, the Norton Priory Collection is predominantly male burials with low numbers of females and non-adult burials. However, this is typical of a monastic site (Knüsel *et al.,* 1995; 1997). Nonetheless, this data is now incorporated into a skeletal database, providing a valuable resource for the universities, museums and future research developments. This database is a simple structure for which required fields can easily be searched, but future data can be added. Overall, it holds general information including the site code, context, bone preservation, radiography, photography and if an individual has been subjected to additional analyses (e.g. aDNA, ^{14}C or Isotope analysis). As the demographic profile has been established for each site, a paleodemographic review, a study of human mortality, fertility and migration can be considered for these samples. This permits the review of the lifespan and health of these past populations, developing a life table for which survivorship, life expectancy, and fertility and mortality rates can be deduced (Weiss and Wobst, 1973; Lovejoy *et al*., 1977; Drusini *et al*., 2001). Such analyses will begin to 'paint a picture' of what life was like for these populations but also how these fit within Medieval England.

The main findings of this research surround the prevalence and frequency of 126 NMTs. The 126 NMTs as described and illustrated in Appendix 1 and 2 have been created by the author for ease of interpretation. Unfortunately, it was noted at the start of this research that the availability of clear descriptions and a standard recording procedure was limited and differed between researchers. Buikstra and Ubelaker (1994) attempted to produce a standard for recording some NMTs, but only 28 cranial traits and three postcranial traits were reported, several of which are from Berry and Berry (1976). These, unfortunately, are a poorly described list, and the postcranial traits are NMTs identified in the cervical spine. In the human skeleton, over 400 NMTs have been recognised and to record such a vast number of NMTs for a relatively small skeletal collection, this task may be considered reasonable. However, to apply this amount of data recording to large skeletal assemblages, this task becomes irrational, challenging the researcher to record all ~400 NMTs in a likely time constraint environment. For this thesis, a relatively short list of 126 NMTs was compiled for ease of recording over large skeletal assemblages. These 126 NMTs were chosen due to easy identification and, ease of recording with efficiency for fragmented, incomplete and poorly preserved human skeletal remains. The NMTs selected include traits recorded by Berry and Berry (1967) and Finnegan (1978) who are often used when recording NMTs in archaeological populations (see Chapter 3). To complement the data recording, the author has provided full descriptions (see Appendix 1) and illustrations (see Appendix 2) for ease of interpretation. It must be stressed that a new recording method for NMTs must be established. One issue found in this research is that different NMTs are recorded for each skeletal collection, this makes it difficult to compare between samples. This is discussed further in the study limitations section of this chapter (see 7.3). The author notes that this thesis does not act as a supplement method but identifies the need to aggregate all possible NMTs into one form which can then be applied to all future interpretations.

This research has identified the frequency of each NMT for the Poulton Chapel, St. Owen's Church and Norton Priory Collections. The frequency of each NMT was analysed further to establish any difference in prevalence between the sexes and/or by age-at-death for each sample. These NMTs were divided further by their category type (i.e. genetic, ambiguous and activity-related), to identify if certain NMTs considered genetic in origin were more predominant in one sample when compared to another. Alongside this, the author was keen to establish if any NMTs considered being activity-related differed between each site, identifying possible rural/urban divides between the samples. The last aim of this thesis included the application of the recorded 126 NMTs to hierarchical cluster and burial spatial analysis to identify plausible familial relationships within each sample. The results of these analyses are discussed below.

7.1.1 Poulton Chapel Collection

For this collection, 602 individuals were analysed (non-adults, n=295; males, n=145; and females, n=162). The frequency of the total number of NMTs expressed in a single individual differs between the non-adult and adult sample. Expectedly, non-adults express fewer NMTs than the adults supporting the notion that the expression of NMTs is reflected with increasing age. Thus, as the skeleton of a non-adult develops, the morphology of the skeletal element changes affecting the skeletal variance observed. As expected, the results identified significant differences between the adult and non-adult age-at-death categories. When exploring the non-adult sample, 57 NMTs presented significant differences between the three age-at-death categories, with most NMTs ranking highest for the youngest age category (0 to 4.99 years). This result is somewhat expected as non-adults of this age group are less likely to express NMTs than the other two groups which are further ahead in the ontogenic development (Buikstra, 1972; Perizonous, 1979; and Hauser and De Stefano, 1989). On the other hand, nine NMTs showed significant differences for the adult sample. However, it is assumed that when you reach adulthood, the expression of all NMTs (if one is to express them) would have occurred. In turn, the analysis used to identify which age-at-death category expressed the difference was not applied.

Contrary to expectation, no bilateral differences were reported for the Poulton Chapel sample. The population of Poulton is believed to be a rural farming community (see Chapter 2) and it was assumed that NMTs considered to be activity-related may have identified a side predominance due to the distinct chores of daily routines often depicted in medieval literature (e.g. manuscripts, sculptures, drawings etc.). Statistical analysis was repeated to consider differences between the non-adult and adult sample, between the sexes and, when considering different NMT categories (genetic, activity-related and ambiguous) but no differences were found.

The adult sample was reviewed further to identify if any NMTs exhibited statistically significant differences between the sexes. For this sample, only six NMTs showed such differences with an even spilt of ranks between the males and females. However, when applying the Bonferroni corrected p value, these results are no longer statistically significant. Relatedly, it must be noted that some NMTs were only reported for single sex (see Chapter 5.2) but they did not show as significantly different during the analysis. Other NMTs do show a higher percentage prevalence in one sex than the other (e.g. sagittal bun was reported in five males (83.3%), and one female and; the humeral septal aperture was recorded in 20 females (76.9%) in comparison to only six males). When dividing the NMTs into specific categories (i.e. genetic, ambiguous and activity-related), no differences were found between the sexes for any category. These results are interesting, as the population at Poulton Chapel is considered a farming community and various interpretations of historic literature portray men completing the heavier labour (e.g. ploughing, herding) while the women are often close to home caring for the children, milking cows and feeding the animals (Mortimer, 2008). The assumption here is that the daily roles between men and women do differ and because of this, it was expected that there would be significant difference noted between NMTs considered to be activity-related. However, this is not the case. It is possible that the roles carried out by both sexes although different, essentially leave similar markers in the skeleton. Further research considering the evaluation of additional NMTs and/or muscle markers may be more appropriate in distinguishing possible differences between the sexes for this population.

Following these analysis, a hierarchical clustering dendrogram (based on average linkage within groups and a squared Euclidean distance dissimilarity coefficient) builds the hierarchy from individual elements by progressively merging clusters was applied to this sample in order to identify possible familial relationships. However, only 148 individuals from Poulton Chapel were subjected to this analysis, and the results were unsuccessful in distinguishing any distinct cluster groups (see 6.1.1). These clusters of individuals were subjected to burial spatial analysis, and no clusters were identified within the burial ground (see 6.2.1). Possible reasons for this lack of spatial clustering include the long and extensive use of this cemetery which is clear through the high number of truncated burials (Burrell *et al.,* 2012; 2013). Another factor could be due to the lack of permanent grave markers. It must have been difficult to identify the location of past family members with the interment of the 'newly' dead buried in an area which could be where the rest of the family was buried. Although the hierarchical clustering analysis was unsuccessful in identifying possible familial groups, individual NMTs were subjected to burial spatial analysis with limited results. This section of analysis subjected 576 individuals to review. Numerous NMTs were reviewed, and the procedure failed. However, in some instances, individuals sharing the same NMT were found in adjacent burials especially amongst males and females, females and children, some males are close to other males, and neighbouring children. Speculatively, males and females could be husband and wives buried together, mothers with their children; males buried close to other males could be related through sons, brothers or even as cousins. However, it must be highlighted that a large amount of data is missing. Many individuals do not have an assigned burial location, excavations are still ongoing (particularly to the north side of the Chapel) and the Harris Matrix is yet to be verified. The results of these analyses are speculative and inconclusive at this stage.

7.1.2 St. Owen's Church Collection

For the St. Owen's Church Collection 265 individuals were subjected to analysis (non-adults, n=95; males, n=93; and females, n=77). The frequency of the total number of NMTs expressed in a single individual differs between the non-adult and adult sample. Similar to Poulton Chapel, non-adults express fewer NMTs than the adult sample. As expected and given the information above, there are significant differences between the adult and non-adult age-at-death categories. When reviewing the non-adult sample, 11 NMTs presented significant differences between the three age-at-death categories, ranking highest for the youngest age category (0 to 4.99 years). This result is somewhat expected as non-adults of this age group are less likely to express NMTs than the other two groups which are further ahead in the ontogenic development. On the other hand, three NMTs showed significant differences between the age categories for the adult sample. These data are informative. However, it is assumed that when you reach adulthood, the expression of all NMTs (if one is to express them) would have occurred. Like the Poulton Chapel sample, statistical analysis was not applied to identify which age-at-death category expressed the difference.

For the St. Owen's Church sample, no bilateral differences were reported. All tests were repeated to consider differences between the non-adult and adult sample, between the sexes and when considering different NMT categories (genetic, activity-related and ambiguous). No differences were reported. The adult sample was reviewed further to identify if any NMTs displayed significant differences between the sexes. For this sample, no differences were reported between the sexes although it must be noted that some NMTs were reported for a single sex (see Chapter 5.3) but did not show as significantly different during the analysis. This is interesting because St. Owen's Church is located just outside the city walls of Gloucester and it is assumed that the individuals buried here likely worked within the city (or close by). Similar to Poulton Chapel, the daily routines of life between men and women are often depicted as different suggesting that men and women will exhibit different markers, especially when considering activity-related NMTs. However, no such difference were reported for this sample.

Following these analyses, a hierarchical clustering dendrogram was applied to this sample in order to identify possible familial relationships. For this analysis, 31 individuals from St. Owen's were subjected to review, and the results revealed three possible cluster groups (see 6.1.2). Unfortunately, the archival information for this sample is currently unavailable. This, in turn, provides a lack of information surrounding burial location of the individuals included in this study. It can be speculated that these clusters could suggest possible familial relationships due to the reasonable sample size subjected to this analysis (n=31). However, until the archival information becomes available, all interpretation remains unresolved.

7.1.3 Norton Priory Collection

For this collection, 130 individuals were subjected to analysis (non-adults, n=16; males, n=85; and females, n=29). The frequency of the total number of NMTs expressed in a single individual differs between the non-adult and adult sample. Similar to Poulton Chapel and St. Owen's Church, the non-adults express fewer NMTs than the adult sample. However, this is expected due the distinct differences between the sample sizes but also the expression of NMTs is reflected with increasing age, so as the skeleton of a non-adult develops, the morphology of the skeletal element changes affecting the NMTs observed. As expected, there are significant differences between the adult and non-adult age-at-death categories. When exploring differences within the non-adult sample, only one NMT presented significant differences between the three age-at-death categories, ranking highest for the youngest age category (0 to 4.99 years). However, for the adult sample, 34 NMTs showed significant differences between the adult age-at-death categories. Although this is informative, it is assumed that when you reach adulthood, the expression of all NMTs (if one is to express them) would have occurred. In turn, the analysis used to identify which age-at-death category expressed the difference was not applied.

As seen already for the Poulton Chapel and St. Owen's Church sample, no bilateral differences were reported for the Norton Priory sample either. All tests were repeated to consider differences between the non-adult and adult sample, between the sexes and when considering different NMT categories (genetic, activity-related and ambiguous) but no differences when found. The adult sample was reviewed further to identify if any NMTs exhibited statistically significant differences between the sexes. For this sample, five NMTs showed such differences ranking highest for the male sample. However, it must be noted that some NMTs were only reported for a single sex and often reported at a higher percentage frequency (see Chapter 5.4). This is most likely due to the bias between the samples sizes of both sexes. As Norton Priory is a monastic site, there is a distinct influx of male burials in comparison to female and children burials.

Finally, the results of the hierarchical clustering dendrogram for Norton Priory Collection is the most interesting of the three samples included in this analysis. Here, 61 individuals from Norton Priory were subjected to this analysis and the results identified three distinct clusters of individuals (see 6.1.3). These clusters were subjected to burial spatial analysis and confirms the possibility of familial groups within the burial ground (see 6.2.2). It has already been acknowledged that specific areas of the Priory have been dedicated to specific families (see Chapter 2) and a majority of individuals from a single cluster are located within the north-east Chapel's while the other two clusters are gathered in the Nave and North Aisle. The results of the hierarchal cluster, burial spatial analysis and historical information support the likelihood of familial relationships within this burial ground. However, to be certain that these individuals are truly related, only the retrieval of aDNA can confirm these results. As the burial location data of an individual is known, burial spatial analysis was attempted on individual NMTs for this sample. Here, the results were limited but with some success. Adjacent burials sharing the same NMT were found across the burial ground. Again, this was particularly popular within the north-east Chapel, Nave, North Aisle and the east Cloister walk. It could be speculated that these individuals buried next to one another are likely husband and wives, brothers and sisters, mothers or fathers with their children or cousins. With much anticipation, confirmation of familial relationships between these burials at Norton Priory cannot be confirmed at this stage, but it does highlight the usefulness of recording NMTS as these could be used as an indicator for identifying possible familial relationships.

7.2 Inter-Population Review

The Poulton Chapel, St. Owen's Church and Norton Priory Collections are unique regarding sample size, rural and urban divides and by social segregation although there is a remarkable amount of overlap. The demographic profile of each sample follows similar trends in distribution, the treatment and manner of burials all follow a Christian manner on an east-west alignment (excluding the three reversed burials from Poulton Chapel) and, each site lays on the western border of England within close proximity to the Welsh Border. It was assumed that there might be a difference in the frequency of NMTs related to activity between each site. Specifically, between the rural Poulton Chapel and the urban St. Owen's Church Collections, or as a social divide to the monastic Norton Priory Collection. However, no activity-related NMTs were found higher in frequency within a single sample, nor were any significant differences found when exploring bilateral differences for each site. Interestingly, for the Poulton Chapel and Norton Priory sample, some NMTs did present statistically significant differences between the sexes. However, when applying the Bonferroni correction, these results were no longer significant. Additionally, these traits differed between each site. No differences were found between the sexes for the St. Owen's Church sample. As expected, significant age-at-death differences were found between the adult and non-adult sample for each site. Typically, when reviewing the non-adult age-at-death categories, most NMTs showed significant differences within the youngest age-at-death category. When reviewing for age-at-death differences for the adult sample of each site, some NMTs did present significant differences between the age-at-detach categories, but no overlap was found between the three sites. No additional analysis was applied to review the adult age-at-death categories further as full expression of any NMT (if likely to get one) should already be expressed by adulthood (Buikstra, 1972; Perizonous, 1979; and Hauser and De Stefano, 1989).

Separately, each sample was compared directly against each other and unsurprisingly, presented differences between the sites, but there are some interesting similarities. Overall, 13 NMTs presented a significant difference between the Poulton Chapel, St. Owen's Church and Norton Priory Collections. Upon further review, it was noted that Poulton Chapel and Norton Priory share 60 NMTs. Only a few NMTs are shared with St. Owen's Church (see Chapter 5.5). This high frequency of shared NMTs between Poulton

Chapel and the Norton Priory Collections is likely due to the geographic location of these two sites (see Chapter 2), as both sites are closely related to one another in comparison to the St. Owen's Church Collection, which is located much further south. This suggests the possibility of a regional divide between the north and southern site.

Alongside this, other skeletal assemblages were selected for comparative data of the 126 NMTs recorded for the Poulton Chapel, St. Owen's Church and Norton Priory collections. The aim here was to establish how these three collections fit within Medieval Britain. However, finding sufficient comparative samples was more difficult than first anticipated especially when trying to extrapolate data of postcranial NMTs. Overall, comparative data were found for 44% of the NMTs included in this thesis and the comparative data ranged from the Saxon period through to Modern samples (Chapter 5.6). Up in till now, no comparison has been made with other archaeological sites and the implications of these comparisons could benefit osteological research. However, it must be noted that there are no certain answers. Unfortunately, the NMT data sets of the comparative assemblages included in this thesis (see Chapter 5.6) do not cover all the NMTs recorded in this thesis, the sexes are pooled and non-adults have been excluded. In turn, this provides comparative data just for the adult sample. In order to make these comparisons, the sexes were pooled for the Poulton Chapel, St. Owen's Church and Norton Priory Collections (see Table 39 and 40). Some notable percentage differences were reported for some NMTs. For the samples reviewed in this thesis, there is a higher percentage of metopism in comparison to the other skeletal assemblages. The frequency of the bregma ossicle is very low for all samples, while the frequency of the coronal ossicle varied across all the samples with the highest percentage of 12% identified in the Spitalfields Collection. The parietal foramen, mastoid foramen, lambdoid ossicle and asterion ossicle were all remarkably low in the Poulton Chapel, St. Owen's Church and Norton Priory Collections when compared to the comparative samples. Most postcranial NMTs presented similar frequency percentages between all samples that reported postcranial traits.

The Wharram Percy Collection was selected to be a good comparison site to Poulton Chapel as they are both Medieval churchyards with a large number of burials. Furthermore, Mays *et al.,* (2007) also applied hierarchical cluster analysis to their data set to identify groups of individuals sharing similar combinations of NMTs. However, like the Poulton Chapel sample, they had little success and suggest that the lack of clustering could be due to the sites long period of use, similar to Poulton Chapel. The

Spitalfields and St. Brides Collections are both named collections are believed to provide insight into NMTs shared between family members. Unfortunately, the results from these comparisons have not provided any valuable information as the majority of the NMTs presented similar percentage frequencies for each sample. Although there are up to 400 individuals in the 'Named' Spitalfields Collection, few NMTs were identified within known family groups (Molleson and Cox, 1993). In their analysis, an aunt and nephew from one family shared a double-rooted canine while a brother and sister shared an asterion ossicle (right side only). For another family, two individuals displayed a bregma ossicle while within another family, two children presented a metopic suture with extra lambdoid sutural ossicles. Overall, Molleson and Cox (1993) summarised that "in general, few relationships could be summarised from the occurrence of non-metric traits". Interestingly, they had more success noting metrical and anthropological similarities (e.g. stature) within family groups than NMTs alone. On the other hand, Berry (1967) reviewed sex differences of 33 cranial NMTs within the St. Brides Collection (Berry, 1967) and found some statistical differences. However, these differed to the comparative sites used in their study. They also differ to the NMTs displayed sex differences for the Poulton Chapel and Norton Priory sample. Interestingly, Berry (1967) does suggest the use of pathological variants as an indication of familial lineage. In this paper, a cervical and sacral cleft was observed in an adult individual who was recorded to have two children. One of these children exhibited a sacral cleft. However, no evidence of clustering for the recorded NMTs was found in this collection (Berry, 1967).

Overall, there appears to be no consistency between NMTs that display statistical differences within the samples included in this thesis and those reported in other research (Berry and Berry, 1965; Berry, 1967; Buikstra, 1972; Finnegan, 1978; Korey, 1980; Hauser and De Stefano, 1989; and Molleson and Cox, 1993; Mays *et al.,* 2007). This suggests that they are the results of an outward manifestation of genetic or environmental influence and not as a result of the gene action itself. The effects of age-at-death do show some influence in the non-adult samples for the Poulton Chapel, St. Owen's Church and Norton Priory samples. However, non-adults are not recorded in other archaeological collections (Dodo, 1974; Berry, 1975; and Perizonous, 1979) and it is difficult to observe if these results are similar to other sites. Once more, like the variability in the differences observed between the sexes, there appears to be no consistency between the NMTs reported with significant age-at-death differences. However, if non-adults are to be considered within future NMT research, these data can be compared to other samples. Nonetheless, when considering age-at-death differences in the adult sample, some NMTs are reported to have significant differences. However, these results are erroneous as all NMTs should be fully expressed by adulthood (Buikstra, 1972; Perizonous, 1979; and Hauser and De Stefano, 1989). Another consideration is the lack of accuracy in the assessment of age-at-death for adults in archaeological populations. This is primarily due to a variety of extrinsic factors that affect the assessment of age (Aykroyd *et al.,* 1999) which can affect the overall ageing of an adult individual. Finally, it appears that the use of NMTs to distinguish familial relationships in some studies are largely inconclusive, but the use of NMTs alongside other metrical and anthropological analysis may provide some insight. However, for confirmation, aDNA will be required to clarify such relationships although there are additional limitations to such investigations (e.g. preservation of the archaeological material and curatorial permissions).

7.3 Study Limitations

For most research concerning human skeletal remains, this research was limited by sample size and sample preservation. Nonetheless, the aims of this study have been met and provide an insight into some of the skeletal variation apparent within the Poulton Chapel, St. Owen's Church and Norton Priory Collections. However, this information has been limited in determining plausible familial relationships using NMTs. The only sample which shows some promise falls with the Norton Priory Collection. Unfortunately, several limitations were noted during this research including the NMTs selected for review, the sites selected for research and the statistics used for analysis. To develop a true understanding of intra and interpopulation variability and familial relationships, biological, geographical and temporal distances should be reviewed. This does provide further scope for extended research on these collections (see 7.4). Nonetheless, a summary of these limitations is highlighted below.

7.3.1 Population Size and Within Population Variability

The demographics of the Poulton Chapel, St. Owen's Church and the Norton Priory Collections provide an insight to just a segment of the people that once occupied these communities. An issue frequently observed when with working with archaeological human skeletal remains is the realisation that the sample excavated is only a small and an unrepresentative sample of the living population from which they derived. This limitation often occurs due to incomplete excavations of a cemetery. There are many additional factors and variables that lead to incomplete excavations (e.g. money, time restraints etc.) and often cannot be avoided. For the three sites included in this thesis, we are aware that the excavations at St. Owen's Church and Norton Priory are now closed and are incomplete. On the other hand, excavations at Poulton Chapel are ongoing, and a substantial sample is available for analysis (n=726). This is a generous sample of the population but not a complete representation of the living population. Alongside this, there is a significant area of the cemetery waiting to be excavated particularly to the north and eastern sides of the Chapel. It has been highlighted that there are divides within and between families (Pearson, 1993) and by social segregation in numerous burial grounds. Poulton Chapel could present such segregations especially during the later phases of the Chapels usage when the Manley family leased the land during the late 15th to early 16th centuries. However, until excavations and the Harris Matrix are complete, these concepts cannot be progressed. As the samples included in this thesis are only a representative sample of the living population, with further problematics for sites under longer periods of use, further errors will likely be introduced. For example, further errors can be introduced by dividing such samples into smaller groups (i.e. age-at-death and/or by sex). This may lead to bias in future paleodemographic and palaeopathological analyses. Further considerations must be made to the fragmentary nature of human skeletal remains, especially those of children and women (Bello *et al.,* 2006). As the rates of completion affect the amount of information that can be recorded for each individual, affecting the final sample size of each skeletal variant recorded. Trait loss is unfortunately quite frequent although this is a common occurrence for most human skeletal collections (Mays *et al*., 2006; Holst *et al*., 2008, Vincent and Mays 2009; and Cottage and Wilton, 2011). Alongside this, comparisons to other comparative samples add further complications surrounding inter- and intra-observer error. Typically, Medieval burials share similar burial characteristics. However, these differ when considering samples from other periods (e.g. the Saxons) adding further issues when considering spatial burial organisation. This thesis identified the use of burial spatial analysis for the Poulton Chapel and Norton Priory Collection with limited success. Nonetheless, it must be noted that as excavations continue these clusters may no longer be apparent, especially for the Poulton Chapel sample. Currently, this model identifies the burials in a 2D manner. It may be more valuable to apply a 3D approach for future analyses.

7.3.2 Population Interactions

Another consideration relates to the wider scope of this project, "what is the geographic origin of these individuals?". Unfortunately, little is known about the communities of Poulton Chapel and St. Owen's Church although there is more information surrounding some individuals buried at Norton Priory, especially those who have been interred in stone lid coffins. However, care must be taken in assuming who is buried in the coffin is actually that person who should have been buried in that coffin. At this stage, no attempt has been made to identify the geographic origin of these individuals. So, who are they? Are the individuals from Poulton Chapel, St. Owen's Church and Norton Priory from the local area or are they from further afield? These questions can be addressed through stable isotope analysis, particularly Strontium (Sr) and Oxygen (O) isotopes. Such analyses can provide information on their origin and migration patterns within the U.K. based on distinct geological regions (Haak *et al*, 2008). Currently, two individuals from Poulton Chapel and three from Norton Priory have been selected and subjected to these analyses. The results suggest that they are for the north-west of England (Burrell *et al.,* 2016). This is valuable information for the skeletons subjected to analysis. However, more data is required to understand the demographics of these populations in more detail. Such further analysis will aid in the identification of the identity of the people buried here and if any interactions between the three sites occurred or/if any intermixing was exhibited elsewhere in the U.K.

7.3.3 Additional Comparative Assemblages

The collections included in this thesis were chosen for study on the basis that little or no previous in-depth research has been completed on them. Very little is known about the skeletons excavated and this thesis provided the opportunity to review them here for the first time. However, finding comparative data for these samples brought its own challenges. An issue in this area of research is the difficulty of comparison between the sites due to the different lists of NMTs used by various observers. This means that only full comparisons could be made between each site if the researcher completed their own analysis with their own lists of NMTs. For the three samples included in this study, the list of NMTs selected can be compared directly between the samples. An aim of this thesis was to establish how these collections fit within Medieval Britain but finding comparative data for all 126 NMTs was quite problematic. In the end, only comparative data were found for 44% of the NMTs included in this thesis, inclusive of few postcranial traits. Alongside this, the samples used in the comparative data ranged from the Saxons through to the Modern era. Regarding the application of looking for familial relationships in these collections, it will be valuable to consider other collections for which the family lineages are known or can be extrapolated (e.g. the Spitalfields Coffin Plate Collection and/or the St. Brides Collection). The Spitalfields Collection, included in the comparative data, has 129 related individuals giving 245 related pairs (Molleson and Cox, 1993). Various NMTs were identified within the collection and some traits were shared within the same family. For example, six skulls were examined from one family and two individuals (Nephew and maternal uncle) shared a bregma ossicle. This trait was recorded 11 times in total for the entire collection (Molleson and Cox, 1993). Molleson and Cox (1993) summarised that 'in general few relationships could be surmised from the occurrence of non-metric traits'. For the St. Brides Collection, also included in the comparative data, 186 crania were examined for Berry's (1974) study. Ten different families were thought to contain related individuals. However, no within family clusters were apparent for any NMT in the small families (Berry, 1974). Unfortunately, the use of NMTs in identifying familial relationships were not insightful for these two named collections. Nonetheless, two females from the Poulton Chapel and two males from Norton Priory exhibited a bregma ossicle could they be mother and daughter? Father and son? Sisters? Brothers? Aunt and niece? Uncle and nephew? This NMT showed a possible relation within a family from the Spitalfields Collection (Molleson and Cox, 1993) so it would be valuable to consider aDNA analysis for these individuals. Alongside this, Berry (1974) did review if there was a historical distribution of cranial NMTs within the St. Brides Collection. This was applied to identify if certain NMTs are more frequent within a certain time range. Unfortunately, this approach was unsuccessful. However, the distribution of time for years at birth only ranged from AD 1720 to 1820 (Berry, 1974). It may be valuable to see if the frequency of NMTs changes across time periods within the same geographic area, particularly for those considered to be genetic in origin. A review of other skeletal collections from the counties of Cheshire and Gloucestershire should be made but also compare these to archaeological collections from along the northern and southern parts of England. This thesis presents a difference in frequency of the traits present at least between the north and southern border of Wales; it will be interesting to see how this relates to the rest of the U.K. In the long term, this may permit a review on how the Poulton Chapel, St. Owen's Church and Norton Priory Collections fit within Medieval England.

7.3.4 Additional NMTs

More data can be collected to address the sample size limitations of the study. Other NMTs from across the skeleton (cranial and postcranial) can be added to this data set to build up a stronger profile which in the long term can be used and compared to other databases, including those of known genetic origin. Here only 126 NMTs were recorded, with 26 cranial traits from Berry and Berry (1967), 17 postcranial traits from Finnegan (1978) and a further 80 variants from across the skeleton which includes pathological (Barnes, 1994) and minor (Hauser and De Stefano, 1989) variants. These 126 NMTs have been chosen for analysis due to easy identification and, ease of recording with efficiency for fragmented, incomplete and poorly preserved human skeletal remains. Ossenberg (1976) states that ~200 skeletal variants have been identified in the human crania and only a portion have been represented in this study. Considering the postcrania elements, it will be impossible to consider the recording and analysis of all these variants for a single population. Many traits that are considered pathological (Saunders and Rainey, 2007) are not included in comparison research. This is not unusual as they are not necessarily considered as an NMT. However, this research highlights the value of such traits, especially those of genetic origin (e.g. extra lumbar vertebrae). The NMTs included in this thesis has been reasonably successful in identifying possible familial relationships, at least for the Norton Priory Collection. However, little difference was found in relation to NMTs considered to be related to activity. It would be worthwhile to include more NMTs considered to be activity-related. It is known that the day to day activities do differ between a rural and urban sample highlighting the need to consider other NMTs to explore this notion further. In hindsight, more skeletal traits would have been recorded and included in this research permitting the review of other collections and upstanding skeletal databases.

Overall, the aims of this study have been met and provide an insight into some of the NMT variation apparent within the Poulton Chapel, St. Owen's Church and Norton Priory Collections. However, this research has been limited in identifying familial relationships. An enlarged NMT sample size, additional comparative assemblages and a more standardised recording system would likely resolve the complications mentioned above but at this point, were beyond the scope of this research. Positively, this does provide further scope for extended research on these collections which are discussed below.

7.4 Future Work and Recommendations

Research surrounding NMTs has been reasonably successful in determining familial relationships within an archaeological collection based on burial spatial distribution analyses. The statistical analyses applied in this thesis are appropriate and reliable in meeting the aims of this research. However, once the archival records of St. Owen's Church have been finalised and the Harris Matrix at Poulton Chapel are concluded, reanalysis of the burial distributions as a proxy for familial relationships will occur. This information can be used to help visualise the spatial burial distribution at St. Owen's Church for the first time and understand the location of burials relative to the Medieval Chapel at Poulton, both inside and out of the Chapel walls. This will lead to a further understanding of the different NMTs observed between these three sites. Recent work by Sarfo (2014) applied Keron's 'Proximity Probability' and Hodder and Okell's 'A statistic' to evaluate burial distance and segregation with reasonable success. Identification of geographic distance can be attempted on these collections through a mean measure of divergence. Such analyses have been successful in many previous studies (e.g. Berry and Berry, 1972; Green, 1982; Turner, 1984; and Irish; 1997; 1998). Another consideration should include correspondence analysis, a variant of 'Principle Component Analysis' or PCA. This technique is often applied to examine the interrelations among a set of variables as demonstrated on the crown and root morphology by Irish (2006).

This research has attempted to make some distinctions between the causations of the 126 NMTs reported for this research (i.e. genetic, activity-related or ambiguous). However, most osteological reports to not make a distinction between the causation of various NMTs as most typically group NMTs as either cranial or postcranial traits. Although this further split between NMT distinctions is not valuable for an individual osteological report, this type of grouping may provide more valuable insights to osteological research as a whole. NMTs are fairly easy to record both for complete and fragmented remains and is an inexpensive method to collect such valuable data. Permitting this further grouping of NMTs can provide an insight into the daily life of past populations. NMTs considered genetic in origin can provide information about possible genetic familial relationships within a single assemblage and with neighbouring populations especially when aDNA retrieval is not permitted, or the preservation of the material is poor. NMTs that are considered activity-related can provide an insight into habitual activities that may be in high frequency within a specific group of individuals. However, as NMTs are not often evaluated in osteological research, the aetiology of some NMTs, especially those considered ambiguous are left unknown. The author believes that such NMTs should still be recorded for osteological collections as the information value may currently be unknown, the author is hopeful that there may be a hidden value that could be discovered in future research. Alongside this, there are further issues regarding the distinctions between the recording methods and the further variance frequently observed for a single NMT (see 6.5). It is planned that the illustrations and descriptions developed by the author (see Appendix 1 and 2) will be finalised into a detailed method that will prove valuable for future research. The nature and aetiology of these NMTs may be more precise to study in the field of bioarchaeology with an improved and standardised recording method.

Another consideration of the 126 NMTs recorded in this study is the application of morphological differences in bone shape and size is worthy of further review. Also, the intertrait association between specific NMTs. These notions were not considered for this thesis, but such variations of individual NMTs and their metrics were recorded. For example, the shape of the bregma ossicle for the Poulton Chapel Collection was on average 2.5cm by 3cm while for the Norton Priory Collection, the average size of this ossicle was smaller. Metopism is a commonly recorded NMT for each sample. However, a partial metopic suture was often recorded, and this often exhibited even further variation, and this differed again between each sample (Burrell *et al.,* 2017). Finally, the location of selective NMTs (e.g. zygomaticofacial foramen and the accessory infraorbital foramen) varied, and although the value of this information is unclear of this stage, the author believes it may provide information when thoroughly evaluated. The use of geo-morphometrics as an aid to identifying differences in size and shape between certain skeletal elements will highlight key differences between the sexes but also the effects these morphologies have on the skeletal variants observed. Finally, a review of intertrait association should be considered for this data set. In osteological research, some NMTs are reviewed on an individual basis. However, this does not necessarily mean they are independent. Often multiple sutural ossicles were recorded within a single individual, or individuals with metopism also exhibited an ossicle at lambda. The consideration of NMTs that fall under a common fundamental process (i.e. an inferior talus double articular facet and double calcaneal articular facet) are likely to be associated with one another, whereas others are largely independent of one another. A further review of these intertrait associations and variations within specific NMTs could provide more valuable information. Essentially, such additional information could provide a deeper insight into possible familial relationships, and this notion will be explored in future research.

A final thought believes the use of other palaeopathological evidence and manifestations of diseases with a genetic influence (e.g. Paget's Disease of Bone) could be included as a proxy when reviewing familial relationships. However, the application of aDNA establishes the true genetics and familial bonds within and between population groups. Unfortunately, this is not always possible due to the preservation of the remains. Town (2016) has demonstrated this issue for some samples within the Poulton Chapel Collection, and the amplification of aDNA has been unsuccessful. Separately, aDNA is being attempted for six individuals from the Norton Priory Collection with Paget's Disease of Bone as part of a Wellcome Trust funded project. Although the results are still pending, the genetics behind the understanding of Paget's Disease of Bone has been established, at least for Modern samples (Siris *et al*., 1991; Hoking *et al.,* 2002; and Eekhoff *et al.,* 2004). Nonetheless, there has been some success through mtDNA as a means for identifying proteins of Paget's Disease of Bone within the Norton Priory Collection (Green, 2016; pers. comms.). The structure of this disease has allowed for proteins to be congealed together, protecting the structure and permitting these analyses. The prevalence of this disease within the Norton Priory and Poulton Chapel Collection is remarkably high (Burrell *et al*., 2016) but may be valuable as this work progresses. Through standardisation of this method, it is hopeful that the amplification of genes related to rare skeletal variants could be highlighted to determine familial links within this collection.

Chapter 8 Conclusion

Summary and Conclusions

The research aims of this thesis were to determine the prevalence and frequency of NMTs found within the Medieval Poulton Chapel, St. Owen's Church and Norton Priory Collections. Each sample was evaluated individually, compared against each other and then to other comparative skeletal assemblages. Additional aims were established to explore any significant differences in the frequency, between the sexes and age-at-death categories while exploring burial spatial distribution analysis to identify possible familial groups within a cemetery context. To meet these requirements, a 126 NMTs (55 cranial and 71 postcranial) were examined in 997 individuals from the Poulton Chapel (n=602), St. Owen's Church (n=265) and the Norton Priory (n=130) Collections. Full descriptions and illustrations have been developed by the author (see Appendix 1 and 2) for this study.

This thesis has provided a detailed account of the population demographics for each collection while identifying the prevalence and percentage frequency of 126 NMTs. This study has found that for the Poulton Chapel Collection, there are no significant differences between the sexes or by different age categories for the adult sample. However, the St. Owen's Church collection noted significant differences between the sexes, specifically for genetic NMTs. No differences were found for the age categories of the adult sample. Finally, Norton Priory exhibited significant sex differences for NMTs consider genetic and ambiguous in origin, and no differences were found between the age categories for the adult sample. Overall, significant differences were found for the non-adults of all three samples and usually complied of NMTs considered genetic in origin. This is to be expected for all samples due to the continuous ontonogy of the non-adult skeleton. No significant differences were found between the sexes with a focus towards NMTs considered ambiguous or activity-related. It was assumed that there might be activity differences between the three samples, specifically between the rural Poulton Chapel and the urban St. Owen's Church Collections, or as a social divide to the monastic Norton Priory Collection. However, no activity-related NMTs were specific or higher in frequency within a single sample, nor were there any significant differences between the sexes. The intra-population review identifies that Poulton Chapel and Norton Priory share 60 NMTs while St. Owen's Church only shares seven NMTs with Norton Priory and just three with the Poulton Chapel sample. This suggests a likely geographical north-south divide between these three sites. Interestingly, some NMTs are reported at a much higher percentage frequency within a single sample. The most notable is the high number of vertebral anomalies within the Poulton Chapel Collection. Such a high percentage of interesting variants highlights a possible gene pool for this sample.

The thesis aimed to establish possible familial relationships using NMTs. The hierarchal cluster analysis provided plausible results of distinguishing familial lineages for the Norton Priory Collection and this was supported by the burial spatial analysis within the Priory ruins. However, this was not successful for the Poulton Chapel or St. Owen's Church Collection. St. Owen's Church was invalid due to the lack of archival information whereas Poulton Chapel is an extensively used site for burials and no long-standing grave markers were used. While at Norton Priory, ornate stone coffins identified the location of *past* burials leading to the achievement of this approach. When focusing on the burial spatial analysis of individual NMTs little information was retrieved. Some NMTs were flagged as possible familial groups for the Norton Priory Collection. However, the evidence of this analysis can only be treated with speculation until aDNA is retrieved from these samples.

This study has identified the lack of a standardised scoring system or method for recording NMTs across archaeological investigations. This has posed complications in retrieving enough comparison data for this research. Current osteological reports only report a selective few NMTs, and these differ between each site. To attain enough comparison data an extensive amount of osteological reports is required to meet the number of NMTs reported in this thesis. Alongside this, current literature review NMTs on an individual basis. It is hopeful that this research, with the supporting illustrations and descriptions provided by the author, will provide a new acknowledgement to record NMTs as a standard protocol for all osteological reports. This will aid future comparisons of NMTs between sites across the UK and further afield. Further issues have been identified between the sample sizes included in this thesis and with the comparative data. However, in some cases, this cannot be avoided.

Overall, this study has introduced the use of NMTs as an aid for identifying plausible familial relationships with the Poulton Chapel, St. Owen's Church and Norton Priory Collections. It has been suggested that some NMTs could provide some insight into familial relationships. However, without the conclusion of archival research and aDNA analysis, we are unable to answer if these results are reliable.

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Appendix

1 Descriptions of NMTs

Accessory Clavicle Facet *(Cause: Activity-related)*

The Accessory Clavicle Facet is defined when the conoid tubercle, the attachment site of the conoid ligament on the lateral, inferior portion of clavicle becomes enlarged and smooth in form. When a smooth oval surface is observed, it is recorded as present (1) or as absent (0) if no facet is seen. The Accessory Clavicle Facet can be recorded for both left and right sides.

Accessory Infraorbital Foramen *(Cause: Genetic)*

The Accessory Infraorbital Foramen lies inferior to the orbital cavity, most commonly found superior to the maxillary first and second premolars (Apinshasmit *et al.,* 2006). The Accessory Infraorbital Foramen serves as an entry point for the maxillary nerve, varying in size and directionality. When visible it is scored as present (1), occasionally a second foramen will be seen adjacent to the infraorbital foramen and is also scored (2). When the trait is not present it is scored as absent (0). The Accessory Infraorbital Foramen can be recorded for both left and right sides.

Accessory Lesser Palatine Foramen *(Cause: Ambiguous)*

The Accessory Lesser Palatine Foramen lies on the posterior border of the palate, posterior to the greater palatine foramen. These foramina can vary in size, shape and directionality. When these foramina are complete, it is scored as present (1). In some instances, double foramina occur and can be scored (3) and when no Accessory Lesser Palatine Foramen are present, it is simply recorded as absent (0). This trait can be recorded for both left and right sides.

Accessory Lumbar Facet *(Cause: Ambiguous)*

The Accessory Lumbar Facet can be identified by a small oval facet located on the spinous process of the lumbar neural arch. This must be reflected on the corresponding vertebrae to be recorded. The Accessory Lumbar Facet can be scored on a presence (1) and absent (0) basis.

Accessory Sacral Facet *(Cause: Activity-related)*

The Accessory Sacral Facet can be observed on the ilium, located on the lilac tuberosity or on the sacral tuberosity on the posterior surface of the sacrum, usually lateral to the second sacral foramen (Ehara *et al.,* 1988). A facet has to be clear on one or both elements to be scored as present (1). If no facet is seen, it is scored as absent (0). The Accessory Sacral Facet can be scored for both left and right sides.

Acetabular Crease *(Cause: Genetic)*

The Acetabular Crease can be found on the articular surface of the acetabulum of the Os Coxae. When present, an indentation or crease is apparent in the anterosuperior quadrant of the surface of the acetabulum (1) and can vary in size (Mafart, 2005). If no depression is seen it is recorded as absent (0). The Acetabular can be recorded for both left and right sides.

Acromion Articular Facet *(Cause: Activity-related)*

The Acromion Articular Facet is found on the inferior surface of the acromial process and is usually oval in form, lying posteriorly to the attachment of the coracoacromial ligament (Finnegan, 1978). When visible it is scored at present (1) or if no facet is seen, it is scored as absent (0). The Acromion Articular Facet can be recorded for both sides.

Allen's Fossa *(Cause: Activity-related)*

The Allen's Fossa (or cervical fossa of Allen), is located near the anterior superior margin of the femoral neck. This fossa is a small depression which make be surrounded by a roughened, thick ridge (Meyer, 1924). When visible it is scored at present (1) or absent (0). The Allen's Fossa can be recorded for both sides and must not be confused with a Poirier's Facet or Plaque Formation.

Anterior Condylar Canal *(Cause: Ambiguous)*

The Anterior Condylar Canal is a foramen that enters the anterior portion of the Occipital Condylar for the Hypoglossal Nerve (Berry and Berry, 1967). When visible it is recorded as present (1). Occasionally, multiple entries can be seen and can be recorded (3). When the Anterior Condylar Canal is not present, it is scored as absent (0). The Anterior Condylar Canal can be recorded for both left and right sides.

Asterion Ossicle *(Cause: Genetic)*

The Asterion Ossicle is a supernumerary suture bone that occurs at the junction of the posterior inferior angle of the parietal bone with the occipital bone and the mastoid portion of the temporal bone. These ossicles vary in size and shape and are noted on both the exocranial and endocranial surfaces of the cranial vault. If a Asterion Ossicle is observed, it is scored as present (1) however, if no sutural bones are visible, they are scored as absent (0). The Asterion Ossicle is recorded for both left and right sides.

Auditory Torus *(Cause: Ambiguous)*

The Auditory Torus is a benign lesion, composed of a dense mass of bon, that is located on the posterior wall and protruding slightly from the external auditory meatus (Miladinović-Radmilović, 2010). If such a lesion is seen, it is recorded as present (1) and absent (0) if no lesion is seen. The Auditory Torus can be recorded for both sides.

Bifid Rib *(Cause: Genetic)*

A Bifid Rib is an irregular variation of a typical rib. A Bifid Rib is the bifurcation of the sternal end of the rib and it can vary in length and location. It typically affects the 3rd, 4th and 5th rib and is recorded on a presence (1) and absent (0) basis for both left and right sides.

Bifurcation of C1 Anterior Neural Arch *(Cause: Genetic)*

The Bifurcation of C1 Anterior Neural Arch is a developmental delay of the neural arches leading to bifurcation or clefting (Barnes, 1994). Bifurcation affects both neural arches, allowing them to meet but not fuse. It is recorded on a presence (1) and absent (0) basis. This must not be confused with Clefting of the C1 Anterior Neural Arch which is when there is a wide flare separating the two neural arches.

Bifurcation of C1 Neural Arch *(Cause: Genetic)*

The Bifurcation of C1 Neural Arch is a developmental delay of the neural arches leading to bifurcation or clefting (Barnes, 1994). Bifurcation affects both neural arches, allowing them to meet but not fuse. It is recorded on a presence (1) and absent (0) basis. This must not be confused with Clefting of the C1 Neural Arch which is when there is a wide flare separating the two neural arches.

Bifurcation of L5 Neural Arch *(Cause: Genetic)*

The Bifurcation of L5 Neural Arch is a developmental delay of the neural arches leading to bifurcation or clefting (Barnes, 1994). Bifurcation affects both neural arches, allowing them to meet but not fuse. It is recorded on a presence (1) and absent (0) basis. This must not be confused with Clefting of the L5 Neural Arch which is when there is a wide flare separating the two neural arches.

Bifurcation of L6 Neural Arch *(Cause: Genetic)*

The Bifurcation of L6 Neural Arch is a developmental delay of the neural arches leading to bifurcation or clefting (Barnes, 1994). Bifurcation affects both neural arches, allowing them to meet but not fuse. It is recorded on a presence (1) and absent (0) basis. This must not be confused with Clefting of the L6 Neural Arch which is when there is a wide flare separating the two neural arches.

Bifurcation of S1 Neural Arch *(Cause: Genetic)*

The Bifurcation of S1 Neural Arch is a developmental delay of the neural arches leading to bifurcation or clefting (Barnes, 1994). Bifurcation affects both neural arches, allowing them to meet but not fuse. It is recorded on a presence (1) and absent (0) basis. This must not be confused with Clefting of the S1 Neural Arch which is when there is a wide flare separating the two neural arches.

Bifurcation of S2 Neural Arch *(Cause: Genetic)*

The Bifurcation of S2 Neural Arch is a developmental delay of the neural arches leading to bifurcation or clefting (Barnes, 1994). Bifurcation affects both neural arches, allowing them to meet but not fuse. It is recorded on a presence (1) and absent (0) basis. This must not be confused with Clefting of the S2 Neural Arch which is when there is a wide flare separating the two neural arches.

Block Fusion of C2 and C3 *(Cause: Genetic)*

Errors in segmentation of the vertebral column lead to the development of Block Vertebrae and as a congenital defect, it varies amongst populations. To identify Block Fusion of C2 and C3, both the second and third cervical vertebrae must be fused at the body and neural arch, this can then be recorded as present (1). If they remain as separate entities, Block Fusion of C2 and C3 is recorded as absent (0).

Block Fusion of C3 and C4 *(Cause: Genetic)*

Errors in segmentation of the vertebral column lead to the development of Block Vertebrae and as a congenital defect it varies amongst populations. To identify Block Fusion of C3 and C4, both the third and fourth cervical vertebrae must be fused at the body and neural arch, this can then be recorded as present (1). If C3 and C4 are separate, Block Fusion of C3 and C4 is recorded as absent (0).

Block Fusion of C4 and C5 *(Cause: Genetic)*

Errors in segmentation of the vertebral column lead to the development of Block Vertebrae and as a congenital defect it varies amongst populations. To identify Block Fusion of C4 and C5, the fourth and fifth cervical vertebrae must be fused at the body and neural arch, this can then be recorded as present (1). If both entities remain separate, Block Fusion of C4 and C5 is recorded as absent (0).

Block Fusion of C5 and C6 *(Cause: Genetic)*

Errors in segmentation of the vertebral column lead to the development of Block Vertebrae and as a congenital defect it varies amongst populations. To identify Block Fusion of C5 and C6, both the fifth and sixth cervical vertebrae must be fused at the body and neural arch, this can then be recorded as present (1). If both vertebrae are separate, Block Fusion of C5 and C6 is recorded as absent (0).

Block Fusion of C6 and C7 *(Cause: Genetic)*

Errors in segmentation of the vertebral column lead to the development of Block Vertebrae and as a congenital defect it varies amongst populations. To identify Block Fusion of C6 and C7, both the sixth and seventh cervical vertebrae must be fused at the body and neural arch, this can then be recorded as present (1). If both entities remain separate, Block Fusion of C6 and C7 is recorded as absent (0).

Block Fusion of C7 and T1 *(Cause: Genetic)*

Errors in segmentation of the vertebral column lead to the development of Block Vertebrae and as a congenital defect it varies amongst populations. To identify Block Fusion of C7 and T1, the seventh and first thoracic vertebrae must be fused at the body and neural arch, this can then be recorded as present (1). If they remain as separate entities, Block Fusion of C7 and T1 is recorded as absent (0).

Block Fusion of T7 and T8 *(Cause: Genetic)*

Errors in segmentation of the vertebral column lead to the development of Block Vertebrae and as a congenital defect it varies amongst populations. To identify Block Fusion of T7 and T8, both the seventh and eighth thoracic vertebrae must be fused at the body and neural arch, this can then be recorded as present (1). If both remain separate, Block Fusion of T7 and T8 can be recorded as absent (0).

Block Fusion of T8 and T9 *(Cause: Genetic)*

Errors in segmentation of the vertebral column lead to the development of Block Vertebrae and as a congenital defect it varies amongst populations. To identify Block Fusion of T8 and T9, both the eighth and ninth thoracic vertebra must be fused at the body and neural arch to be recorded as present (1). If both entities are separate, Block Fusion of T8 and T9 is recorded as absent (0).

Block Fusion of T9 and T10 *(Cause: Genetic)*

Errors in segmentation of the vertebral column lead to the development of Block Vertebrae and as a congenital defect it varies amongst populations. To identify Block Fusion of T9 and T10, both the ninth and tenth thoracic vertebrae must be fused at the body and neural arch, this can then be recorded as present (1). If both vertebra is separate, Block Fusion of T9 and T10 is recorded as absent (0).

Block Fusion of T10 and T11 *(Cause: Genetic)*

Errors in segmentation of the vertebral column lead to the development of Block Vertebrae and as a congenital defect it varies amongst populations. To identify Block Fusion of T10 and T11, the tenth and eleventh thoracic vertebrae must be fused at the body and neural arch, this can then be recorded as present (1). If both entities are separate, Block Fusion of T10 and T11 is recorded as absent (0).

Block Fusion of L1 and L2 *(Cause: Genetic)*

Errors in segmentation of the vertebral column lead to the development of Block Vertebrae and as a congenital defect it varies amongst populations. To identify Block Fusion of L1 and L2, both the first and second lumbar vertebrae must be fused at the body and neural arch, this can then be recorded as present (1). If both vertebrae are separate, Block Fusion of L1 and L2 is recorded as absent (0).

Bregmatic Ossicle *(Cause: Genetic)*

The Bregmatic Ossicle is a supernumerary suture bone that occurs at the meeting point of the sagittal and coronal suture. This bone is positioned at the anterior fontanelle and is noted on both the exocranial and endocranial surfaces of the cranial vault (Barberini *et al.,* 2008). This sutural bone can vary in size and shape (Rakesh *et al.,* 2013). When a bregmatic ossicle occurs it is scored as present (1) and is scored when absent (0). Rarely, multiple suture bones occur at this landmark and in turn must be scored (2).

Carabelli's Cusp Maxillary Deciduous 1st Molar *(Cause: Genetic)*

Carabelli's Cusp is a small additional cusp on the crown of the lingual surface of the maxillary deciduous first molar. This supernumerary cusp varies in size and is recorded on a presence (1) and absent (0) basis. The Carabelli's Cusp Maxillary Deciduous 1st Molar can be recorded for both sides.

Carabelli's Cusp Maxillary Permanent 1st Molar *(Cause: Genetic)*

Carabelli's Cusp is a small additional cusp on the crown of the lingual surface of the maxillary first molar. This supernumerary cusp varies in size and is recorded on a presence (1) and absent (0) basis. The Carabelli's Cusp Maxillary Permanent 1st Molar can be recorded for both sides.

Carabelli's Cusp Mandibular Deciduous 1st Molar *(Cause: Genetic)*

Carabelli's Cusp is a small additional cusp on the crown of the lingual surface of the mandibular deciduous first molar. This supernumerary cusp varies in size and is recorded on a presence (1) and absent (0) basis. The Carabelli's Cusp Mandibular Deciduous 1st Molar can be recorded for both sides.

Carabelli's Cusp Mandibular Permanent 1st Molar *(Cause: Genetic)*

Carabelli's Cusp is a small additional cusp on the crown of the lingual surface of the mandibular first molar. This supernumerary cusp varies in size and is recorded on a presence (1) and absent (0) basis. The Carabelli's Cusp Mandibular Permanent 1st Molar can be recorded for both sides.

Cervicothoracic Cranial Border Shift *(Cause: Genetic)*

When there is a shift in the cervicothoracic border, the seventh cervical vertebrae attempt to move down the vertebral column and becomes thoracic in form, this often leads to a cervical rib (Barnes, 1994). If a

Cervicothoracic Cranial Border Shift is observed it is recorded as present (1), if no shift is seen, if it recorded as absent (0).

Clefting of C1 Neural Arch *(Cause: Genetic)*

The Clefting of C1 Neural Arch is a developmental delay of the neural arches leading to bifurcation or clefting (Barnes, 1994). Clefting affects both neural arches and they appear flared, separating the two neural arches. If clefting of the neural arches are observed, it is recorded as present (1). If no clefting is seen, it is recorded as absent (0). This must not be confused with Bifurcation of the C1 Neural Arch which is when the two neural arches meet but are not fused.

Clefting of L5 Neural Arch *(Cause: Genetic)*

The Clefting of L5 Neural Arch is a developmental delay of the neural arches leading to bifurcation or clefting (Barnes, 1994). Clefting affects both neural arches and they appear flared, separating the two neural arches. If clefting of the neural arches are observed, it is recorded as present (1). If no clefting is seen, it is recorded as absent (0). This must not be confused with Bifurcation of the L5 Neural Arch which is when the two neural arches meet but are not fused.

Clefting of L6 Neural Arch *(Cause: Genetic)*

The Clefting of L6 Neural Arch is a developmental delay of the neural arches leading to bifurcation or clefting (Barnes, 1994). Clefting affects both neural arches and they appear flared, separating the two neural arches. If clefting of the neural arches are observed, it is recorded as present (1). If no clefting is seen, it is recorded as absent (0). This must not be confused with Bifurcation of the L6 Neural Arch which is when the two neural arches meet but are not fused.

Clefting of S1 Neural Arch *(Cause: Genetic)*

The Clefting of S1 Neural Arch is a developmental delay of the neural arches leading to bifurcation or clefting (Barnes, 1994). Clefting affects both neural arches and they appear flared, separating the two neural arches. If clefting of the neural arches are observed, it is recorded as present (1). If no clefting is seen, it is recorded as absent (0). This must not be confused with Bifurcation of the S1 Neural Arch which is when the two neural arches meet but are not fused.

Clefting of S2 Neural Arch *(Cause: Genetic)*

The Clefting of S2 Neural Arch is a developmental delay of the neural arches leading to bifurcation or clefting (Barnes, 1994). Clefting affects both neural arches and they appear flared, separating the two neural arches. If clefting of the neural arches are observed, it is recorded as present (1). If no clefting is seen, it is recorded as absent (0). This must not be confused with Bifurcation of the S2 Neural Arch which is when the two neural arches meet but are not fused.

Congenital Absence of Thoracic Vertebra *(Cause: Genetic)*

The Congenital Absence of Thoracic Vertebrae is the result of a numerical error of somites than related to a border shift. Missing somites are considered rare (Barnes, 1994). All vertebrae must be present to account for 24 pre-sacral segments; seven cervical, twelve thoracic and five lumbar vertebrae. If a

Congenital Absence of Thoracic Vertebra is reported this can be recorded as present (1). If twelve vertebra segments are present it is recorded as absent (0).

Congenital Absence of Dentition *(Cause: Genetic)*

The Congenital Absence of Dentition relates to the identification of a missing tooth or teeth (Graber, 1978). Here, confirmation of such missing teeth can be clarified through radiographic analysis and can affect any tooth but most typically the maxillary lateral incisors. Congenital Absence of Dentition can be recorded on a presence (1) and absence (0) basis.

Coronal Button Osteoma (*Cause: Ambiguous)*

A Coronal Button Osteoma is often described as a smooth circular bony overgrowth that can be found on the cranial vault. Most cranial osteomata are asymptomatic and go unnoticed in clinical reports (Eshed *et al.,* 2002). These protrusions are often found solitary and can vary in size along the coronal suture. When a single osteoma is visible it is scored as present (1), sometimes clusters of osteomata are seen and are also scored (2). When no osteomata are visible, the trait is scored as absent (0). Coronal osteomata are recorded for both left and right sides.

Coronal Ossicle *(Cause: Genetic)*

The Coronal Ossicle is a supernumerary suture bone that occurs along the coronal suture, not exceeding the junction of the coronal suture and the greater wing of the sphenoid. These ossicles vary in size and shape and are noted on both the exocranial and endocranial surfaces of the cranial vault. When this sutural bone is presented it is scored as present (1). Occasionally multiple ossicles develop and are scored (2). When no sutural bones are visible, they are scored as absent (0). Coronal Ossicles can be recorded for both left and right sides.

Double Atlas Articular Facet *(Cause: Activity-related)*

The Double Atlas Articular Facet is located on the superior surface and can vary in size and shape. Here an oval facet is either separated by a groove or ridge of bone creating two discrete facets which be scored as present (1) or as absent if this trait is not observed (0) and can be scored for both sides. This is not to be confused with the Single Atlas Articular Facet.

Double Calcaneal Articular Facet *(Cause: Activity-related)*

The Double Calcaneal Articular Facet is located on the superior surface medially to the Peroneal Tubercle. The surface can vary in size and shape. Here an hour glass shaped facet with two discrete facets can be scored as present (1) or as absent (0) and can be scored for both sides. This is not to be confused with the Single Calcaneal Articular Facet.

Double Occipital Condylar Facet *(Cause: Activity-related)*

The Double Occipital Condylar Facet is located on the inferior surface of the crania, lateral to the foramen magnum. Like most facets, they can vary in size and shape. Here an oval facet is either separated by a groove or ridge of bone creating two discrete facets can be scored as present (1) or if this trait is not observed, it is recorded as absent (0) The Double Occipital Condylar Facet can be scored for both sides. This is not to be confused with the Single Occipital Condylar Facet.

Enamel Pearl *(Cause: Genetic)*

An Enamel Pearl is an ectopic globule of enamel that adheres to the tooth root surface. It can be found on any tooth but more commonly the molars (Darwazeh and Hamasha, 2000). When an Enamel Pearl is exhibited it is recorded as present (1) or if it not seen, it is scored as absent (0).

Epipteric Ossicle *(Cause: Genetic)*

The Epipteric Ossicle is a supernumerary suture bone that is located between the anterior inferior angle of the parietal bone and the greater wing of the sphenoid. These ossicles vary in size and shape and are noted on both the exocranial and endocranial surfaces of the cranial vault. If the Epipteric Ossicle is large it may articulate with the squamous part of the temporal bone (Berry and Berry, 1967). When this sutural bone is presented it is scored as present (1); when no sutural bones are visible, they are scored as absent (0). The Epipteric Ossicle is recorded for both left and right sides.

Extra Lumbar Vertebra *(Cause: Genetic)*

An Extra Lumbar Vertebra is the result of numerical errors in the somites rather than related to a border shift. Extra somites are unusual but not as rare as missing vertebra (Barnes, 1994). All vertebrae must be present to account for 24 pre-sacral segments; seven cervical, twelve thoracic and five lumbar vertebrae. If an Extra Lumbar Vertebra is present and six are counted, this can be recorded as present (1). If five vertebral segments are present, it is recorded as absent (0).

Extra Thoracic Vertebra *(Cause: Genetic)*

An Extra Thoracic Vertebra is the result of numerical errors of in the somites rather than related to a border shift. Extra somites are unusual but not as rare as missing vertebra (Barnes, 1994). All vertebrae must be present to account for 24 pre-sacral segments; seven cervical, twelve thoracic and five lumbar vertebrae. If an Extra Thoracic Vertebra is present and thirteen are counted, this can be recorded as present (1). If twelve vertebra segments are present it is recorded as absent (0).

Femoral Anteversion *(Cause: Ambiguous)*

Femoral Anteversion is the inward twisting of the femoral diaphysis, causing the distal epiphyses to face more medially. There is variability within and between population groups, however if there is an increased rotation to the shaft of the femur, Femoral Anteversion is recorded as present (1). If not, distinct twist is seen it is recorded as absent (0).

Femoral Osteoma *(Cause: Ambiguous)*

A Frontal Osteoma is often described as a smooth bony overgrowth that can be found on the diaphysis shaft of the femur. Most osteomata are asymptomatic and go unnoticed in clinical reports (Eshed *et al.,* 2002). These protrusions are often found solitary and can vary in size. A Femoral Osteoma is oval in length and can be found along the diaphysis. When a single osteoma is visible it is scored as present (1), sometimes clusters of osteomata are seen and are also scored (2). When no osteomata are visible, the trait is scored as absent (0).

Femoral Supracondylar Process *(Cause: Activity-related)*

The Femoral Supracondylar Process, similarly to the Humeral Supracondylar Process, is a bony projection that arises from the anterior medial surface of the Femur, proximal to the medial epicondyle. The Femoral Supracondylar Process is usually pointed, directed distally and can vary in length. It is recorded as present (1) or absent (0), and for both sides.

Flared Rib *(Cause: Genetic)*

A Flared Rib is an irregular variation of a typical rib. Here the sternal end of the rib is enlarged and fan like and recorded on a presence (1) and absent (0) basis for both sides.

Foramen Ovale *(Cause: Ambiguous)*

The Foramen Ovale is found on the inferior of the crania. The posterior wall of the Foramen Ovale is incomplete so that the foramen is continuous with the Foramen Spinosum. It is recorded on a present (1) and absent (0) basis for both left and right sides.

Foramen Spinosum Open *(Cause: Ambiguous)*

The Foramen Spinosum Open is found on the inferior of the crania. The posterior wall of the Foramen Spinosum is incomplete. It is recorded on a present (1) and absent (0) basis for both left and right sides.

Frontal Bun *(Cause: Ambiguous)*

The Frontal Bone consists of two halves which fuse together during early childhood. However, in some individuals a raised edge runs along where these two halves met, creating a slight bunning affect from the nasion to the bregma. If such bunning occurs it is recorded as present (1); if no bunning is seen if it recorded as absent (0).

Frontal Button Osteoma *(Cause: Ambiguous)*

A Frontal Button Osteoma is often described as a smooth circular bony overgrowth that can be found on the cranial vault. Most cranial osteomata are asymptomatic and go unnoticed in clinical reports (Eshed *et al.,* 2002). These protrusions are often found solitary and can vary in size. When a single osteoma is visible it is scored as present (1), sometimes clusters of osteomata are seen and are also scored (2). When no osteomata are visible, the trait is scored as absent (0). Frontal osteomata are recorded for both left and right sides.

Frontal Foramen *(Cause: Genetic)*

The Frontal Foramen is a small aperture located laterally to the Supraorbital Foramen on the supraorbital ridge of the frontal bone, superior to the orbital cavity and lateral to the nasion. These foramina can vary in size, shape and directionality. When these foramina are complete it is scored as present (1). In some instances, double foramina occur and are scored (3) and when no Frontal Foramina are present, it is simply recorded as absent (0). These are recorded for both left and right sides.

Frontal Temporal Articulation *(Cause: Genetic)*

The Frontal Temporal Articulation occurs when the frontal and temporal bones are in direct contact. Normally, the frontal bone is separated from the temporal bone by the greater wing of the sphenoid and/or the anterior angle of the parietal bone (Berry and Berry, 1967). When the frontal temporal articulation occurs, it is scored as present (1) and scored as absent (0) if articulation does not occur.

Highest Nuchal Line *(Cause: Activity-related)*

The Highest Nuchal Line is a well-marked ridge running horizontally across the occipital bone. It arises superior to the external occipital protuberance and arches anteriorly and laterally (Berry and Berry, 1967). The Highest Nuchal Line is scored as present (1) or absent (0).

Humeral Osteoma *(Cause: Ambiguous)*

A Humeral Osteoma is often described as a smooth bony overgrowth that can be found on the diaphysis of the humerus. Most osteomata are asymptomatic and go unnoticed in clinical reports (Eshed *et al.,* 2002). These protrusions are often found solitary and can vary in size. A Humeral Osteoma is oval in length and can be found along the diaphysis. When a single osteoma is visible it is scored as present (1), sometimes clusters of osteomata are seen and are also scored (2). When no osteomata are visible, the trait is scored as absent (0).

Humeral Supracondylar Process *(Cause: Activity-related)*

The Humeral Supracondylar Process is a bony projection that arises from the anterior medial surface of the humerus (Subasi *et al.,* 2002), proximal to the medial epicondyle. The Humeral Supracondylar Process is usually pointed, directed distally and can vary in length. It is recorded as present (1) or absent (0) and for both sides.

Humeral Septal Aperture *(Cause: Activity-related)*

The Humeral Septal Aperture is a perforation in the bone that separates the coronoid fossa from the olecranon process in the supratrochlear area of the distal portion of the humerus (Mays, 2008). It is scored on a present (1) and absent (0) basis and for both sides.

Huschke Foramen *(Cause: Ambiguous)*

The Huschke Foramen is a foramen that is always present in children and rarely persists into adulthood. It is located on the inferior aspect of the temporal ring, near the external auditory meatus (Herzog and Fiese, 1989). If fusion fails to complete along the anterior inferior aspect, the Huschke Foramen is formed and scored as present (1) or if it is closed, it is recorded as absent (0), The Huschke Foramen can be recorded for both sides.

Hypotrochanteric Fossa *(Cause: Activity-related)*

The Hypotrochanteric Fossa is in the superior posterior portion of the femoral diaphysis near the gluteal ridge on the lateral margin. The Hypotrochanteric Fossa is found in close approximation to the Third Trochanter (Finnegan, 1978) and can vary in shape and size. If a fossa is present it is scored as 1 and if no changes are observed it is scored as absent (0). The Hypertrochanteric Fossa can be scored for both sides.

Ilium Foramen *(Cause: Genetic)*

The Ilium Foramen is a small aperture located superiorly to the auricular surface. These foramina can vary in size, shape and directionality. When this foramen is complete it is scored as present (1). In some instances, double foramina occur and are scored (3). When no Ilium Foramen is exhibited, it is simply recorded as absent (0). These are recorded for both left and right sides.

Inferior Talus Double Articular Facet *(Cause: Activity-related)*

The Inferior Talus Double Articular Facet is located on the inferior surface of the head of the talus and can be a single surface or divided into two surfaces (Finnegan, 1978). The Inferior Talus Double Articular Facet must contain two surfaces to be recorded as present (1). Otherwise it is recorded as absent (0). It can be recorded for both sides. This must not be confused with the Inferior Talus Single Articular Facet.

Inferior Talus Single Articular Facet *(Cause: Activity-related)*

The Inferior Talus Single Articular Facet is located on the inferior surface of the head of the talus and can be a single surface or divided into two surfaces (Finnegan, 1978). The Inferior Talus Single Articular Facet must be a single surface to be recorded as present (1). Otherwise it is recorded as absent (0). It can be recorded for both sides. This must not be confused with the Inferior Talus Double Articular Facet.

Lambdoid Ossicle *(Cause: Genetic)*

The Lambdoid Ossicle is a supernumerary suture bone that occurs along the lambdoid suture, not exceeding the junction of the lambdoid suture and the parietal bone. These ossicles vary in size and shape and are noted on both the exocranial and endocranial surfaces of the cranial vault. When this sutural bone is presented it is scored as present (1). Occasionally multiple ossicles develop and are scored (2). When no sutural bones are visible, they are scored as absent (0). The Lambdoid Ossicle are recorded for both left and right sides.

Late Eruption of Canines *(Cause: Genetic)*

Occasionally, the canines erupt quite late either protruding over the lateral incisor leading to displacement of the canines. When this is exhibited it is recorded as present (1) or absent if this does not occur (0).

Lumbarisation of S1 *(Cause: Genetic)*

When there is a shift in the lumbosacral border, the first sacral vertebral segment attempts to move up the vertebral column, this is known as Lumbarisation of S1, a caudal shift (Barnes, 1994). There are variation if this trait, when complete lumbarisation has occurred it is recorded as present (1), if incomplete, unilateral lumbarisation has occurred, it is recorded as partial (2). Or if no border shift has occurred it is recorded as absent (0).

Lumbarisation of L6 *(Cause: Genetic)*

If an Extra Sacral Vertebrae is exhibited, a shift in the lumbosacral border can still occur. For the Lumbarisation of L6 this sacral vertebral segment attempts to move up the vertebral column, a caudal shift (Barnes, 1994). There is variation if this trait, when complete lumbarisation has occurred it is recorded as present (1), if incomplete, unilateral lumbarisation has occurred, it is recorded as partial (2). Or if no border shift has occurred it is recorded as absent (0).

Mandibular Third Molar *(Cause: Genetic)*

The Mandibular Third Molar erupts between 17 and 25 years of age and can be recorded on a presence (1) and absent (0) basis and for both sides. Radiographs can be obtained to identify the crypt of the toot bud for younger individuals.

Mandibular Torus *(Cause: Ambiguous)*

The Mandibular Torus refers to a lingually bony protuberance of varying size and shape on the lingual surface of the mandible (Hauser and De Stefano, 1989). It is typically found near the pre-molars and molars. When the Mandibular Torus is seen it is recorded as present (1) or if nit protuberance is noted, it is recorded as absent (0). The Mandibular Torus is recorded for both sides.

Mastoid Foramen *(Cause: Genetic)*

The Mastoid Foramen is a small aperture located near the suture between the mastoid part of the temporal bone and the occipital bone (Berry and berry, 1967). These foramina can vary in size, shape and directionality. When these foramina are complete it is scored as present (1). In some instances, double foramina occur and are scored (3) and when no Mastoid Foramen is present, it is simply recorded as absent (0).

Maxillary Third Molar *(Cause: Genetic)*

The Maxillary Third Molar erupts between 17 and 25 years of age and can be recorded on a presence (1) and absent (0) basis and for both sides. Radiographs can be obtained to identify the crypt of the toot bud for younger individuals.

Maxillary Torus *(Cause: Ambiguous)*

The Maxillary Torus refers to a lingually bony protuberance of the alveolar bone of varying size and shape on the lingual surface of the maxilla (Hauser and De Stefano, 1989). It is typically found near the pre-molars and molars. When the Maxillary Torus is seen it is recorded as present (1) or if no protuberance is noted, it is recorded as absent (0). The Maxillary Torus is recorded for both sides.

Metatarsal Osteoma *(Cause: Ambiguous)*

A Metatarsal Osteoma is often described as a smooth bony overgrowth that can be found on any the shaft of a metatarsal. Most osteomas are asymptomatic and go unnoticed in clinical reports (Eshed *et al.,* 2002). These protrusions are often found solitary and can vary in size. A Metatarsal Osteoma is oval in length and can be found along the diaphysis of the Metatarsal. When a single osteoma is visible it is scored as present (1), sometimes clusters of osteomata are seen and are also scored (2). When no osteomata are visible, the trait is scored as absent (0).

Metopism *(Cause: Genetic)*

The frontal suture extends from the nasion to the anterior portion of the bregma intersection. This suture, distinguished by the two halves of the frontal bone, usually disappears during infancy and/or early childhood (Ajmarni *et al.,* 1983). However, for some individuals this suture persists and remains throughout adulthood. This condition is known as metopism. A true persistence of the metopic suture from the nasion to the bregma is scored as present (1). Residual traces of the metopic suture sometimes persist at the nasion, this is scored as a partial metopism (2). Otherwise, when this suture is obliterated, it is recorded as absent (0).

Ossicle at Lambda *(Cause: Genetic)*

The Ossicle at Lambda is a supernumerary suture bone that occurs at the junction of the sagittal and lambdoid sutures, at the position of the posterior fontanelle (Berry and Berry, 1967). These ossicles vary in size and shape and are noted on both the exocranial and endocranial surfaces of the cranial vault. No attempt has been made at this stage to distinguish between Inca Bones formed in this area. When this sutural bone is presented it is scored as present (1). When no sutural bones are visible, they are scored as absent (0).

Occipital Bun *(Cause: Ambiguous)*

An Occipital Bun is a prominent projection that occurs of the occipital bone on the posterior portion of the crania. There is variation in the rejection of this protuberance, all protuberance is recorded as present (1). If no protuberance is seen it is recorded as absent (0).

Occipital Foramen *(Cause: Genetic)*

The Occipital Foramen is a small aperture located on the occipital bone. These foramina can vary in size, shape and directionality. When these foramina are complete they are scored as present (1). In some instances, double foramina occur and are scored (3) and when no Occipital Foramen is present, it is simply recorded as absent (0).

Occipital Osteoma *(Cause: Ambiguous)*

An Occipital Osteoma is often described as a smooth circular bony overgrowth that can be found on the cranial vault. Most cranial osteomata are asymptomatic and go unnoticed in clinical reports (Eshed *et al.,* 2002). These protrusions are often found solitary and can vary in size on the occipital bone. When a single osteoma is visible it is scored as present (1). Sometimes clusters of osteomata are seen and are also scored (2). When no osteomata are visible, the trait is scored as absent (0).

Occipitocervical Cranial Border Shift *(Cause: Genetic)*

When there is a shift in the occipitocervical border, the atlas vertebrae attempt to move up the vertebral column, this is sometimes known as the Atlantooccipital fusion (Barnes, 1994). There is variation if this trait, when a complete cranial shift has occurred it is recorded as present (1), if incomplete, unilateral shifting has occurred, it is recorded as partial (2). Or if no border shift has occurred it is recorded as absent (0).

Palatine Torus *(Cause: Ambiguous)*

The Palatine Torus refers to bony protuberance along the midline suture of the palate, it can vary is shape and size (Hauser and De Stefano, 1989). It can be restricted to the midline but can be seen extended to the lingual surfaces. When the Palatine Torus is seen it is recorded as present (1) or if no protuberance is noted, it is recorded as absent (0).

Parietal Button Osteoma *(Cause: Ambiguous)*

A Parietal Button osteoma is often described as a smooth circular bony overgrowth that can be found on the cranial vault. Most cranial osteomata are asymptomatic and go unnoticed in clinical reports (Eshed *et al.,* 2002). These protrusions are often found solitary and can vary in size along the parietal suture. When a single osteoma is visible it is scored as present (1), sometimes clusters of osteomata are seen and are also scored (2). When no osteomata are visible, the trait is scored as absent (0).

Parietal Foramen *(Cause: Genetic)*

The Parietal Foramen is a small aperture located laterally to the sagittal suture, superior to the lambda junction site. The parietal foramen transmits veins to the dura matter (Moore and Dalley, 2006). These foramina can vary in size, shape and directionality. When these foramina are visible it is recorded as present (1). When the trait is not present it is scored as absent (0). The parietal foramens are recorded for both left and right sides.

Parietal Notch Ossicle *(Cause: Genetic)*

The Parietal Notch Ossicle is a supernumerary suture bone that occurs between the squamous and mastoid portion of the temporal bone. These ossicles vary in size and shape and are noted on both the exocranial and endocranial surfaces of the cranial vault. When this sutural bone is present it is scored as present (1); when no sutural bones are visible, they are scored as absent (0). Parietal Notch Ossicles are recorded for both left and right sides.

Pars Basilaris Depression *(Cause: Genetic)*

The Pars Basilaris Depression is located centrally on the pars basilaris portion of the occipital bone. This depression can vary in size and shape, but if a distinct ridge is seen, the Pars Basilaris Depression is recorded as present (1). If not, depression is seen it is simply recorded as absent (0).

Peg Tooth *(Cause: Genetic)*

A Peg Tooth is abnormal tooth which is much smaller is size with a single cusp. These usually act as a replacement tooth for the third molars or lateral incisors. A Peg Tooth can be recorded on a present (1) and absent (0) basis. It can also be recorded for both sides.

Peroneal Tubercle *(Cause: Activity-related)*

The Peroneal Tubercle can be located on the lateral side of the calcaneus. It can be defined as a tubercle or small facet around the calcaneo-fibular ligament (Finnegan, 1978). It is scored on a present (1) and absent (0) basis. The Peroneal Tubercle can be recorded for both sides.

Plaque Formation *(Cause: Activity-related)*

The Plaque Formation is in the same region as the Poirier's Facet and Allen's Fossa along the anterior superior margin of the femur. However, Plaque Formation is an overgrowth or bony scar that can extend from the area of the Poirier's Facet and it can, rarely, surround or cover the Allen's Fossa (Angel, 1964).

When a rough surface is resent it can be scored as present (1) or if the area is clear, it is scored as absent (0). This variant can be scored for both sides and must not be confused with the smooth surface of the Poirier's Facet or the depression of the Allen's Fossa.

Poirier's Facet *(Cause: Activity-related)*

The Poirier's Facet (or cervical eminence) is located on the articular surface of the head of the femur on the anterior superior margin of the femoral neck (Kostick, 1963). This facet is smooth and when visible can be scored as present (1). If no facet is present, it is scored as absent (0). The Poirier's Facet can be recorded for both sides but must not be confused with the Allen's Fossa or Plaque Formation.

Posterior Condylar Canal *(Cause: Ambiguous)*

The Posterior Condylar Canal enters posteriorly to the Occipital Condylar Facet and is recorded on a present (1) and absent (0) basis. The Posterior Condylar Canal can be recorded for both sides.

Precondylar Tubercle *(Cause: Ambiguous)*

The Precondylar Tubercle is a bony tubercle that lies immediately anteromedial to the Occipital Condylar Facet on the inferior surface of the basilar portion of the occipital bone. That are variations in size and shape. It can be scored on a present (1) and absent (0) basis.

Proximal Phalanx Osteoma *(Cause: Ambiguous)*

A Proximal Phalanx Osteoma is often described as a smooth circular bony overgrowth that can be found on the cranial vault. Most osteomas are asymptomatic and go unnoticed in clinical reports (Eshed *et al.,* 2002). These protrusions are often found solitary and can vary in size. A Proximal Phalanx Osteoma is oval in length and can be found along the diaphysis on the phalanx. When a single osteoma is visible it is scored as present (1), sometimes clusters of osteomata are seen and are also scored (2). When no osteomata are visible, the trait is scored as absent (0).

Sacralisation of L5 *(Cause: Genetic)*

When there is a shift in the lumbosacral border, the fifth lumbar segment attempts to move down the vertebral column, this is known as Sacralisation of the L5, a cranial shift (Barnes, 1994). There is variation of this trait, when complete sacralisation has occurred it is recorded as present (1), if incomplete, unilateral sacralisation has occurred, it is recorded as partial (2). Or if no border shift has occurred it is recorded as absent (0).

Sacralisation of L6 *(Cause: Genetic)*

If an Extra Lumbar Vertebrae (L6) is exhibited, a shift in the lumbosacral border can still occur. For the Sacralisation of L6 this sacral vertebral segment attempts to move down the vertebral column, a cranial shift (Barnes, 1994). There are variations of this trait. When complete sacralisation has occurred, it is recorded as present (1). If incomplete, unilateral sacralisation has occurred, it is recorded as partial (2). Or, if no border shift has occurred it is recorded as absent (0).

Sacroiliac Joint Fusion *(Cause: Ambiguous)*

Fusion of the Sacroiliac Joint is defined by the fusion of the ala wings of the sacrum with the iliac tuberosity and scored on a present (1) and absent (0) basis. Sacroiliac Joint Fusion can occur and be recorded for both sides.

Sagittal Bun *(Cause: Ambiguous)*

The sagittal suture can meet together and create a raised edge from the bregma junction to the lambda junction of the occipital bone. This Sagittal Bun can be recorded as present (1) or if no bunning is seen, it recorded as absent (0).

Sagittal Depression *(Cause: Ambiguous)*

The sagittal suture can meet together and create a depression between the two halves along the bregma junction to the lambda junction of the occipital bone. This Sagittal Depression can be recorded as present (1) or absent (0).

Sagittal Foramen *(Cause: Genetic)*

The sagittal foramen is a small aperture that occurs along the sagittal suture. Like the parietal foramen, it transmits a vein to the dura mater. This foramen is usually small in diameter and the location varies along the sagittal suture. When these foramina are visible, they are recorded as present (1). When the trait is not present, it is scored as absent (0).

Sagittal Ossicle *(Cause: Genetic)*

The Sagittal Ossicle is a supernumerary suture bone that occurs along the sagittal suture, not exceeding the junction of the coronal and lambdoid sutures. These ossicles vary in size and shape and are noted on both the exocranial and endocranial surfaces of the cranial vault. When this sutural bone is presented, it is scored as present (1). Occasionally multiple ossicles develop and are scored (2). When no sutural bones are visible, they are scored as absent (0). The coronal ossicles are recorded for both left and right sides.

Shovel Shaped Incisors *(Cause: Genetic)*

Shovel Shaped Incisors are were the incisors appear scooped out on the lingual margins of the tooth. There are variations in expression but if shovelling is present it is recorded as present (1) or absent if the trait is not exhibited (0).

Sixth Cusp Mandibular Permanent 2nd Molar *(Cause: Genetic)*

Occasionally, a sixth cusp is apparent on the 2nd permanent molar and can be recorded as present (1). Or if only 5 cusps are exhibited, this trait can be recorded as absent (0). The Sixth Cusp Mandibular Permanent 2nd Molar is recorded for both sides.

Single Atlas Articular Facet *(Cause: Activity-related*

The Single Atlas Articular Facet is located on the superior surface and can vary in size and shape. Here a single, oval facet can be present (1) or absent (0) and can be scored for both sides. This is not to be confused with the Double Atlas Articular Facet.

Single Calcaneal Articular Facet *(Cause: Activity-related)*

The Single Calcaneal Articular Facet is located on the superior surface medially to the Peroneal Tubercle. The surface can vary in size and shape, here only a single oval facet is to be scored as present (1) or absent (0) and can be scored for both sides. This is not to be confused with the Double Calcaneal Articular Facet.

Single Occipital Condylar Facet *(Cause: Activity-related)*

The Single Occipital Condylar Facet is located on the inferior surface of the crania, lateral to the foramen magnum. Like most facets, they can vary in size and shape. Here only an oval facet can be scored as present (1) or if this trait is not observed, it is recorded as absent (0) The Single Occipital Condylar Facet can be scored for both sides. This is not to be confused with the Double Occipital Condylar Facet.

Spina Bifida Occulta *(Cause: Genetic)*

Spina Bifida Occulta is the most common developmental defect of the vertebral column (Barnes, 1994) and is defined by the incomplete fusion of the posterior neural arches of the sacrum. When all arches are unfused it is recorded as present (1), if only some segments are affected record as partial (2) or if all neural arches are affected, it can be recorded as absent (0).

Spondylolysis of L4 Neural Arch *(Cause: Genetic)*

Spondylolysis of L4 neural Arch is the identification of the separation of the vertebral neural arch from the vertebral body. This is a congenital defect but can also be related to physical activity (Roberts and Manchester, 2010). When there is a complete Spondylolysis of the L4 Neural Arch it can be recorded as present (1). When there is asymmetrical Spondylolysis it is recorded as partial (2) or, if no Spondylolysis is seen, it is simply recorded as absent (0).

Spondylolysis of L5 Neural Arch *(Cause: Genetic)*

Spondylolysis of L5 neural Arch is the identification of the separation of the vertebral neural arch from the vertebral body. This is a congenital defect but can also be related to physical activity (Roberts and Manchester, 2010). When there is a complete spondylolysis of the L4 Neural Arch it can be recorded as present (1). When there is asymmetrical spondylolysis it is recorded as partial (2) or, if no spondylolysis is seen, it is simply recorded as absent (0).

Spondylolysis of L6 Neural Arch *(Cause: Genetic)*

Spondylolysis of L6 neural Arch is the identification of the separation of the vertebral neural arch from the vertebral body. This is a congenital defect but can also be related to physical activity (Roberts and Manchester, 2010). When there is a complete spondylolysis of the L4 Neural Arch it can be recorded as present (1). When there is asymmetrical spondylolysis it is recorded as partial (2) or, if no spondylolysis is seen, it is simply recorded as absent (0).

Squatting Facet *(Cause: Activity-related)*

The Squatting Facet is located on the lower anterior margin of the distal portion of the tibia. There are variations of the Squatting Facet (Singh, 1959). This study records the depression on the lateral side of this margin and is recorded at present (1) or absent (0). The squatting facet is recorded for both sides.

Sternal Aperture *(Cause: Activity-related)*

The Sternal Aperture is a perforation of the sternal body. It can vary in shape, size and directionality. If an aperture is seen, it is recorded as present (1) and absent if no aperture is seen (0).

Supernumerary Dentition *(Cause: Genetic)*

Occasionally, Supernumerary Dentition can occur and this is defined when the typical number of teeth are exceeded and it can be a single or multiple occurrence (Kumar *et al.,* 2012). This can be recorded on a present (1) and absent basis (0). Supernumerary Dentition can be recorded for both sides.

Supraorbital Foramen *(Cause: Genetic)*

The Supraorbital Foramen is located in the supraorbital margin of the frontal bone, superior to the orbital cavity and lateral to the nasion. The supraorbital foramen is a passage for the supraorbital artery and nerve which provides sensation to the forehead (Chrcanovic *et al.,* 2011). When these foramina are complete, they are scored as present (1). When incomplete, it is scored as partial foramen (2). This must not be confused with a supraorbital notch which has a smoothened edge (see description of Supraorbital Notch). In some instances, double foramina occur and are scored (3) and when no supraorbital foramina are present, it is simply recorded as absent (0). These are recorded for both left and right sides.

Supraorbital Notch *(Cause: Genetic)*

The Supraorbital Notch is located on the superior medial border of the orbital cavity, lateral to the nasion of the frontal bone. It has a similar function to the supraorbital foramina but with different characteristics. Typically, the notch is smooth and elongated in length when compared to the supraorbital foramina. This notch can vary in depth. When a supraorbital notch is present, it is scored as present (1) and if no notch is seen, it is recorded as absent (0). These are recorded for both left and right sides.

Suprascapular Foramen *(Cause: Genetic)*

The Suprascapular Foramen is identified by the complete ossification of the suprascapular ligament over the suprascapular notch (Finnegan, 1978). The Suprascapular Foramen is scored on a present (1) and absent (0) basis. It can also be recorded for both left and right sides.

Talan Cusp *(Cause: Genetic)*

The Talan Cusp is a rare dental anomaly in which a cusp like mass protrudes from the anterior portion of the teeth. It is recorded on a present (1) and absent basis (0).

Third Trochanter *(Cause: Activity-related)*

The Third Trochanter is located on the superior end of the gluteal tuberosity, localised underneath the greater trochanter. The Third Trochanter resembles the lesser trochanter but it is an osseous prominence or tubercle (Bolanowski *et al.,* 2005) oblong in formation. The Third Trochanter can be recorded as present (1) or as absent (0) and for both sides.

Thirteenth Rib *(Cause: Genetic)*

The Accessory Rib is the result of a transitional error in the vertebral column. If a 13th rib is reported and/or 13 rib facets are observed, these are recorded as present (1). If no extra facets are exhibited, it is recorded as absent (0). A Thirteenth Rib can be recorded for both sides.

Thoracolumbar Border Cranial Shift *(Cause: Genetic)*

When there is a shift in the thoracolumbar border, the first lumbar segment attempts to move up the vertebral column (Barnes, 1994) which may lead to the loss of the 12th rib. When a Thoracolumbar Border Cranial Shift occurs, it can be recorded on a presence (1) and absent (0) basis.

Thoracolumbar Border Caudal Shift *(Cause: Genetic)*

When there is a shift in the thoracolumbar border, the twelfth vertebral segment attempts to move down the vertebral column (Barnes, 1994) which may lead to a lumbar rib and transitional rib facets. When a Thoracolumbar Border Caudal Shift occurs, it can be recorded on a presence (1) and absent (0) basis.

Tibia Anteversion *(Cause: Ambiguous)*

Tibia Anteversion is the inward twisting of the tibia diaphysis, causing the distal epiphyses to face more medially. There is variability within and between population groups. However, if there is an increased rotation to the shaft of the tibia, Tibia Anteversion is recorded as present (1). If not, distinct twist is seen it is recorded as absent (0).

Tibia Osteoma *(Cause: Ambiguous)*

A Tibia Osteoma is often described as a smooth bony overgrowth. Most osteomata are asymptomatic and go unnoticed in clinical reports (Eshed *et al.,* 2002). These protrusions are often found solitary and can vary in size. A Tibia Osteoma is oval in length and can be found along the diaphysis. When a single osteoma is visible, it is scored as present (1), sometimes clusters of osteomata are seen and are also scored (2). When no osteomata are visible, the trait is scored as absent (0).

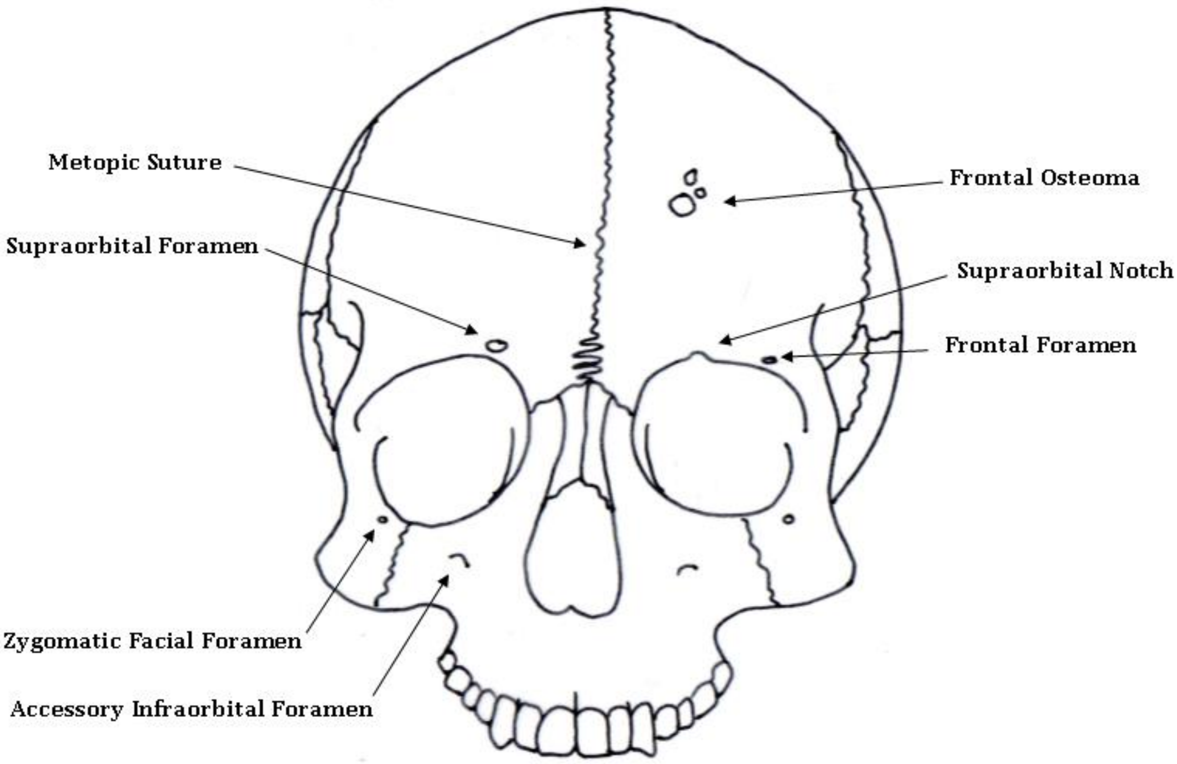
Vastus Notch *(Cause: Genetic)*

The Vastus Notch is a small smooth notch located in the superolateral angle of the patella (Finnegan, 1978). When a distinct concavity is observed it is scored as present (1) and absent (0) if no notch is seen. The Vastus Notch can be scored for both sides.

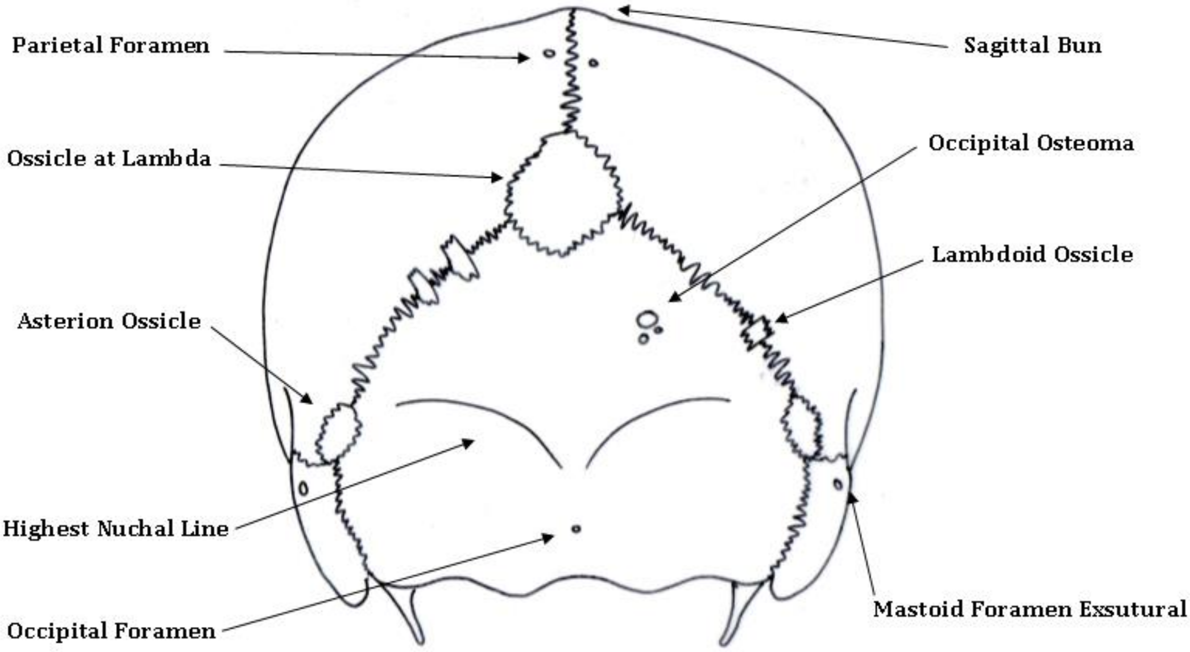
Zygomaticofacial Foramen *(Cause: Genetic)*

The Zygomaticofacial Foramen is located on the lateral border of the zygomatic bone, inferior to the frontal process. The Zygomaticofacial foramen serves as an entry and/or exit site of the zygomatic nerve and blood vessels (Loukas *et al.,* 2008). When visible it is recorded as present (1). Occasionally, the zygomatic bone displays variation in the number of foramina on its facial aspect and is scored (2). When the trait does is not present, it is scored as absent (0). The Zygomaticofacial Foramina are recorded for both left and right sides.

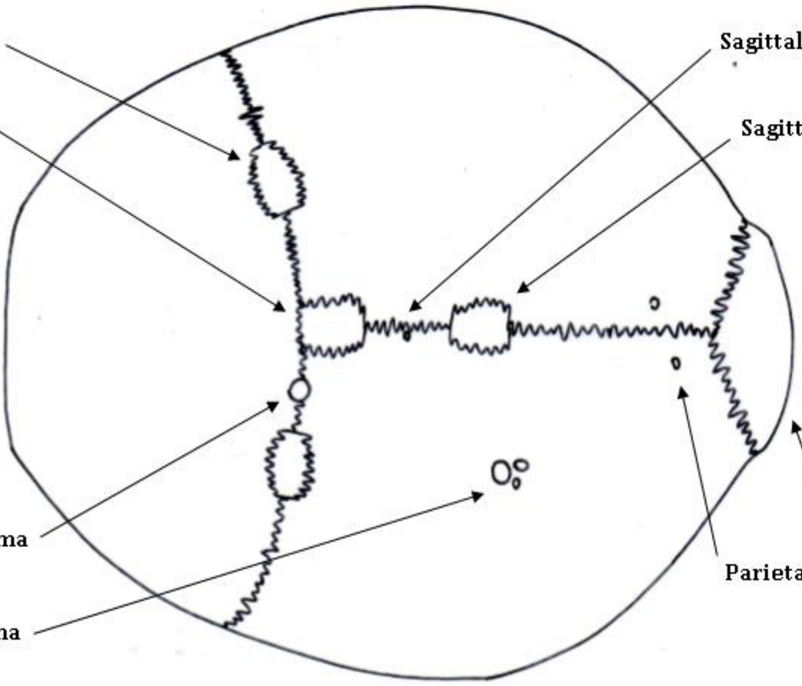
2 Illustrations of NMTs



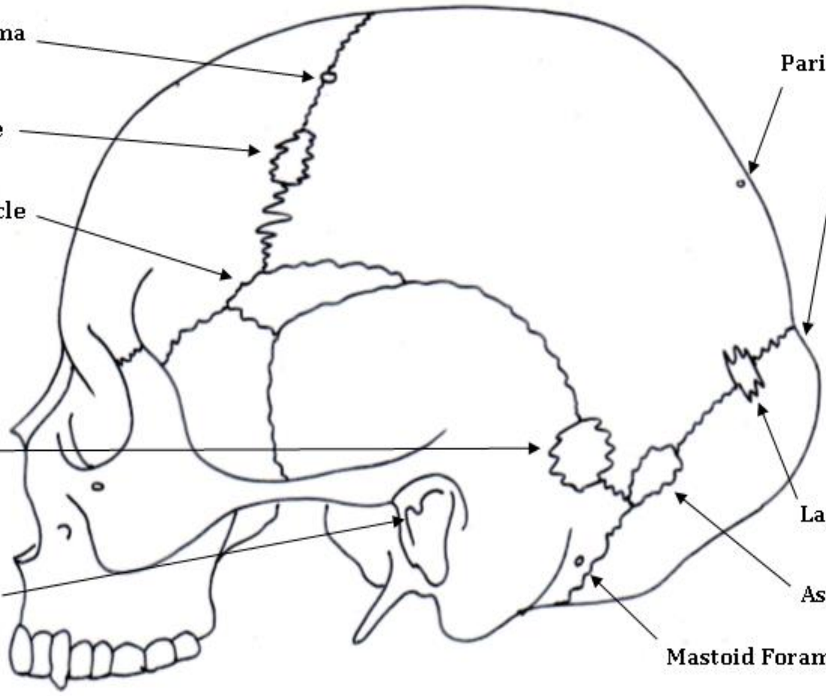
Anterior View of Crania



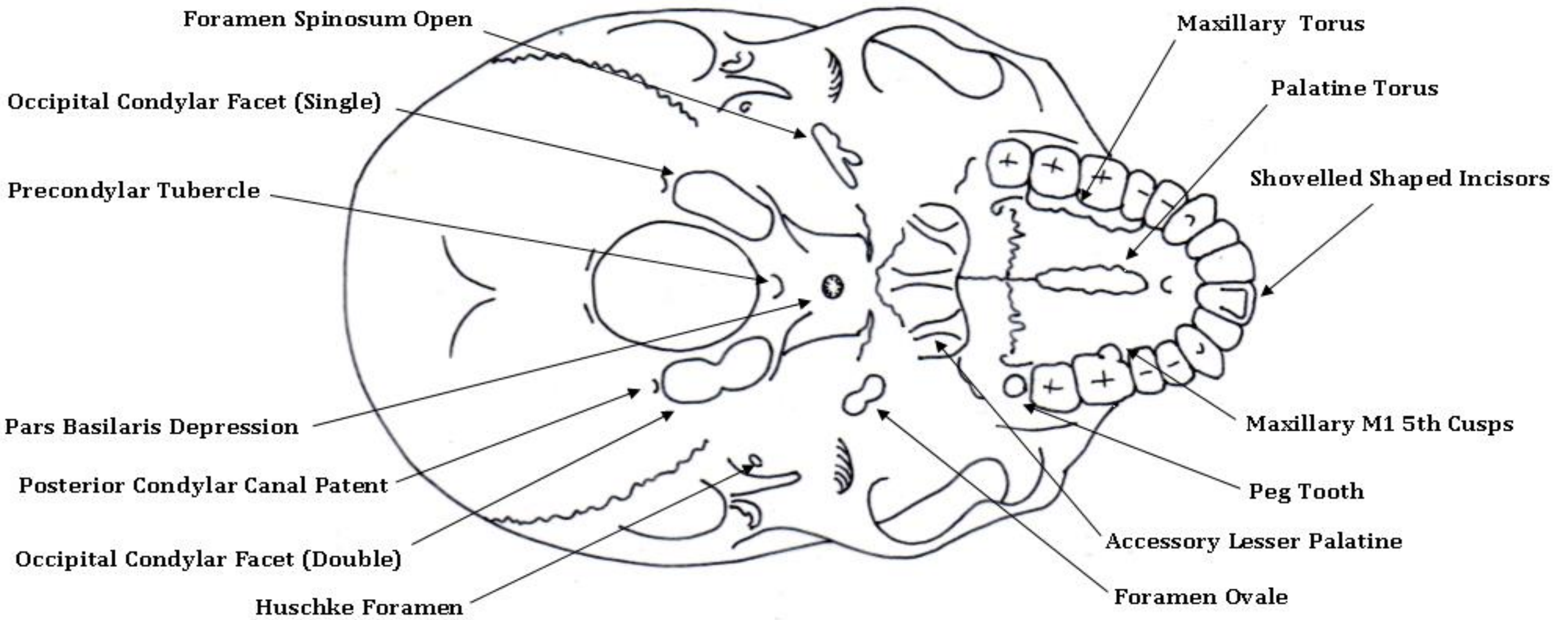
Posterior View of Crania



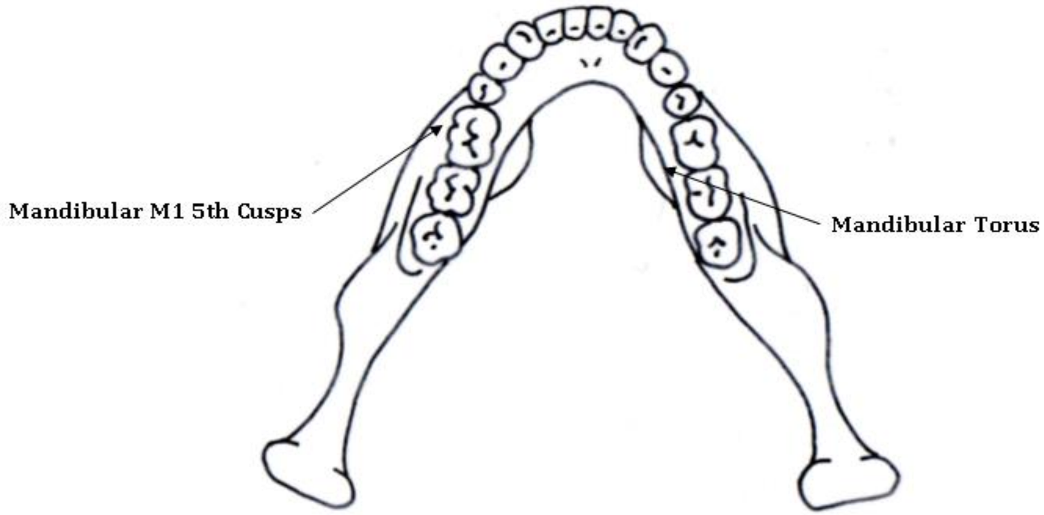
Superior View of Crania



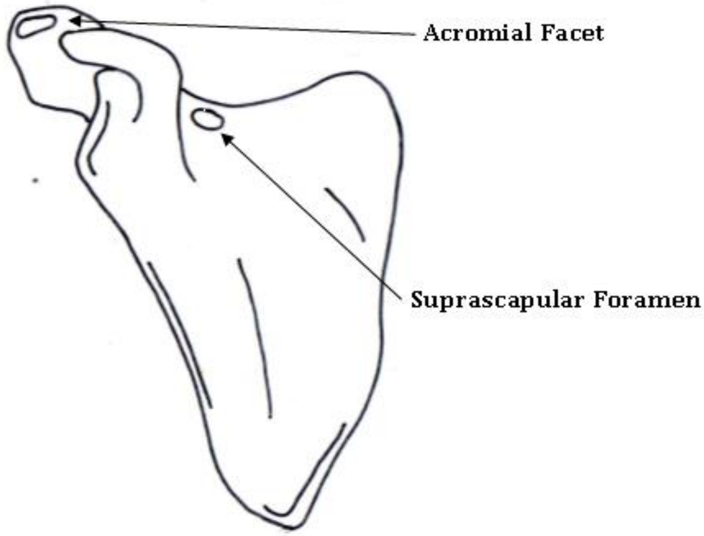
Left Lateral View of Crania



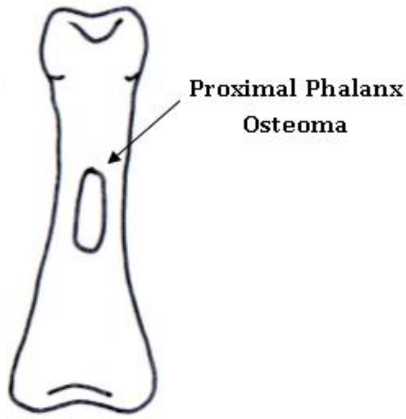
Inferior View of Cranium



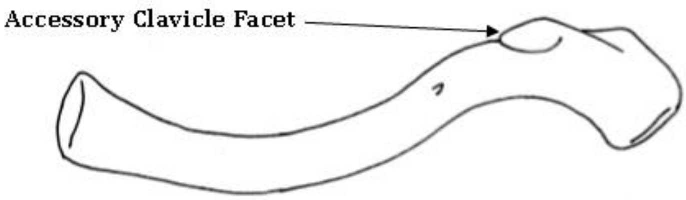
Superior View on Mandible



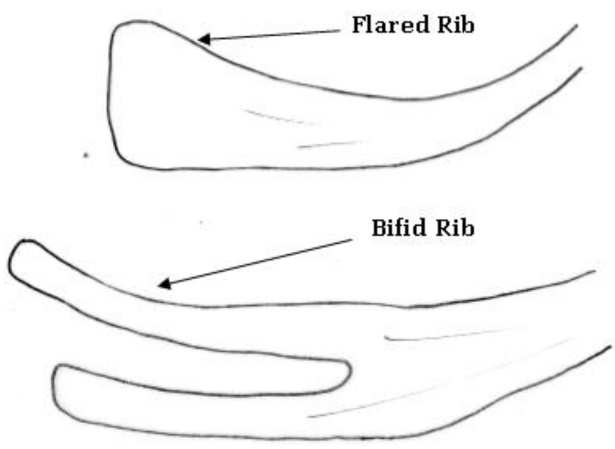
Anterior View of Right Scapular



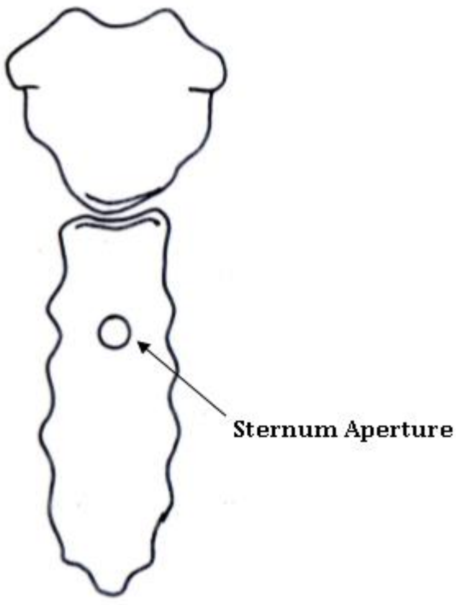
Dorsal View of Right Proximal Phalanx



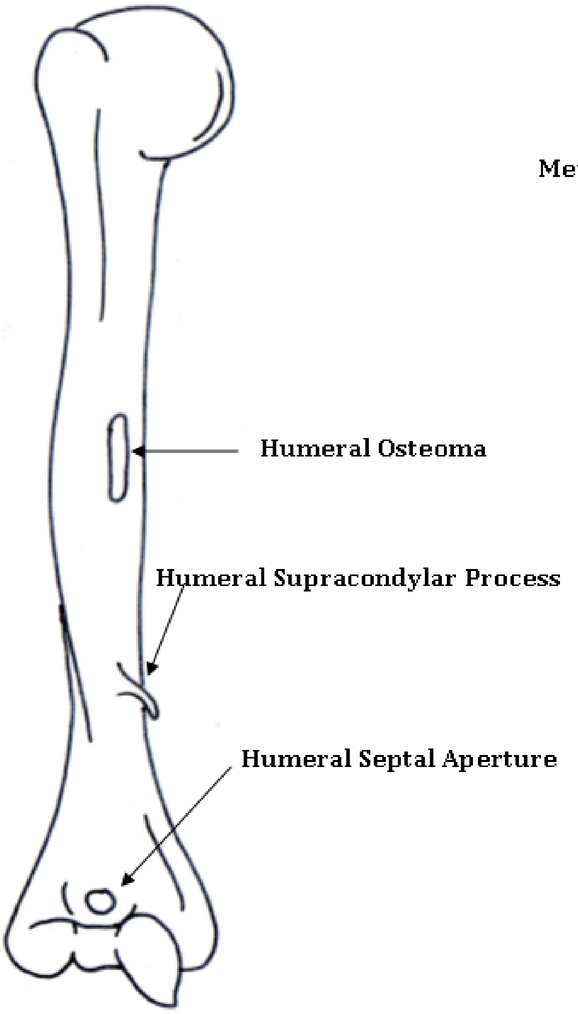
Inferior View of Right Clavicle



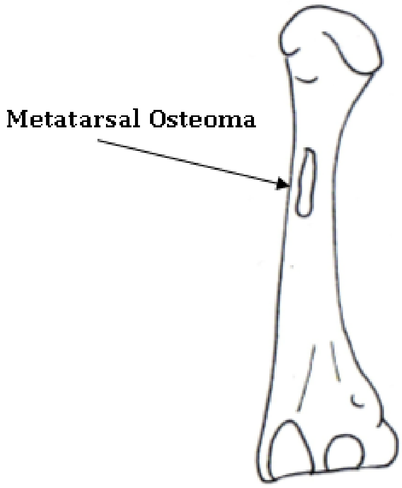
Inferiorposterior View of Right Ribs



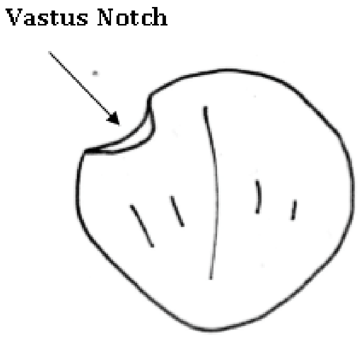
Anterior View of Sternum



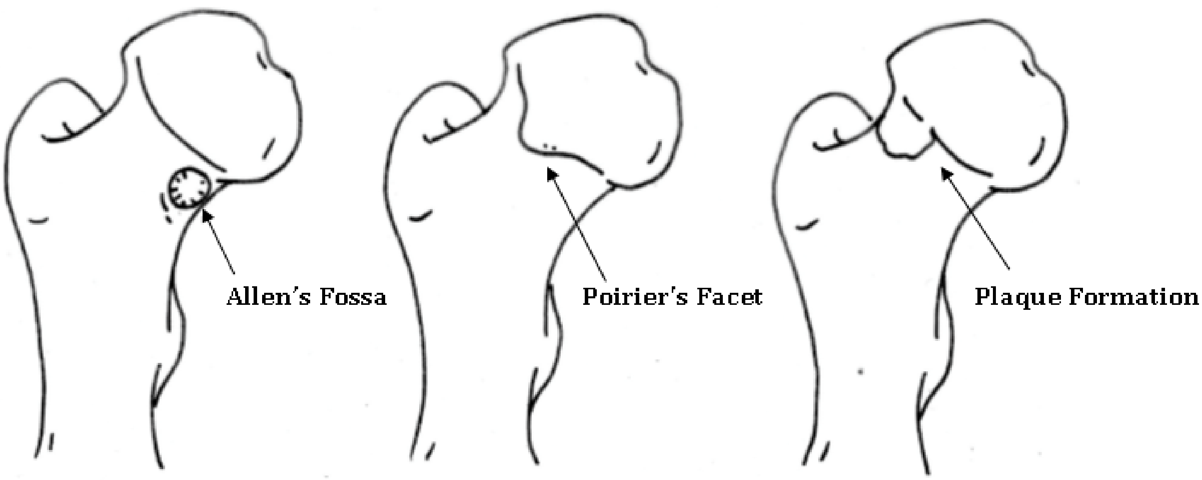
Anterior View of Right Humerus



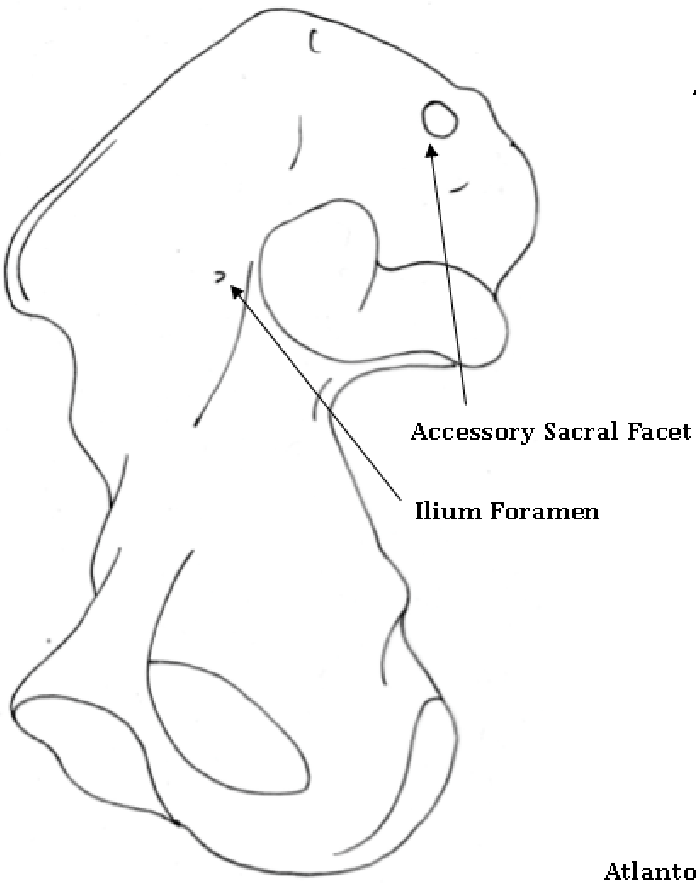
Right Lateral View of Metatarsal



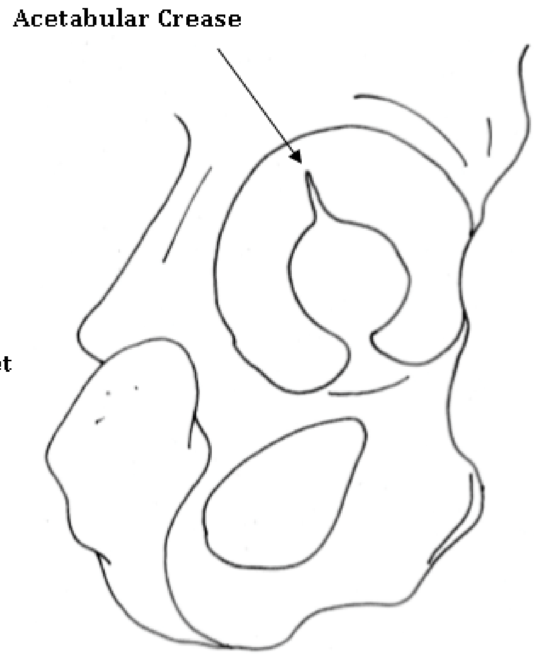
Anterior View of Right Patella



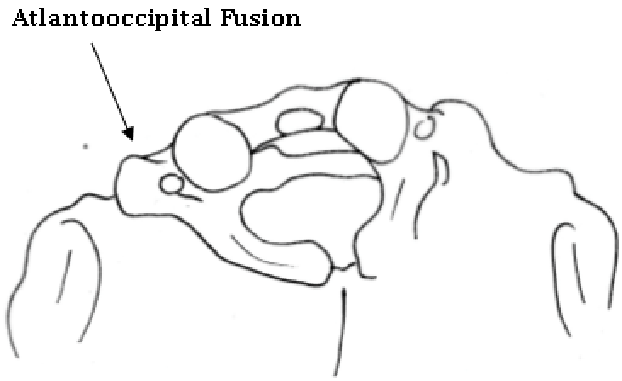
Anterior View of Right Proximal Femur



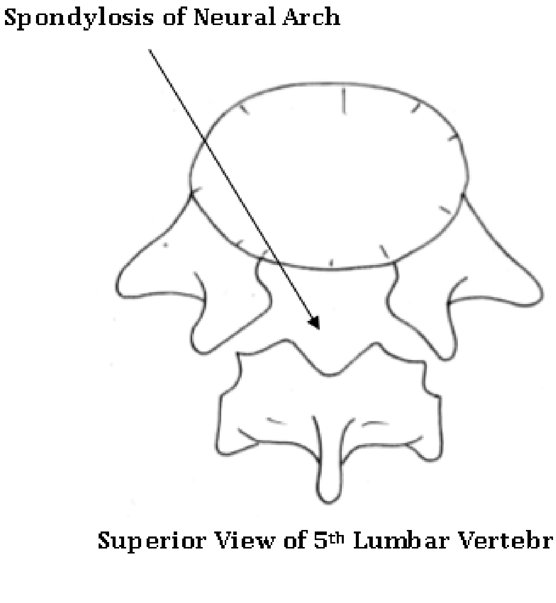
Right Medial View of Os Coxae



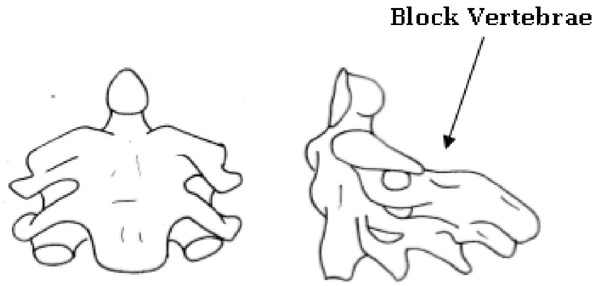
Right Lateral View of Os Coxae



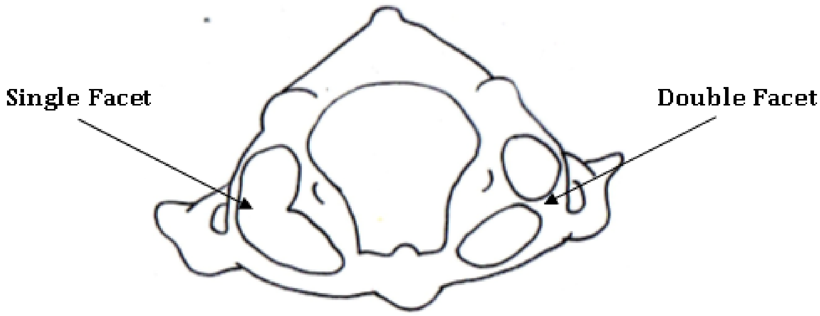
Inferiorposterior View of Cranium



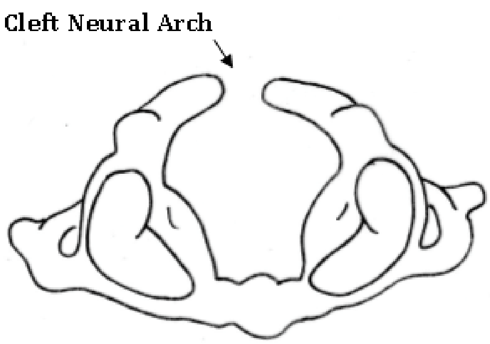
Superior View of 5^{th} Lumbar Vertebrae



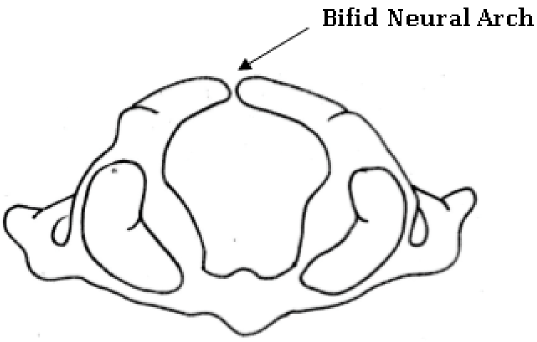
Anterior & Lateral View of 2^{nd} & 3^{rd} Cervical Vertebrae



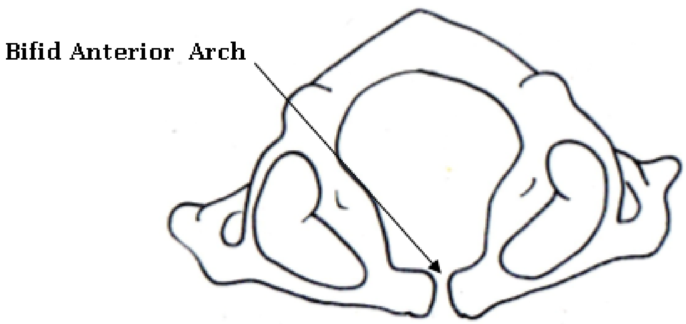
Superior View of Atlas



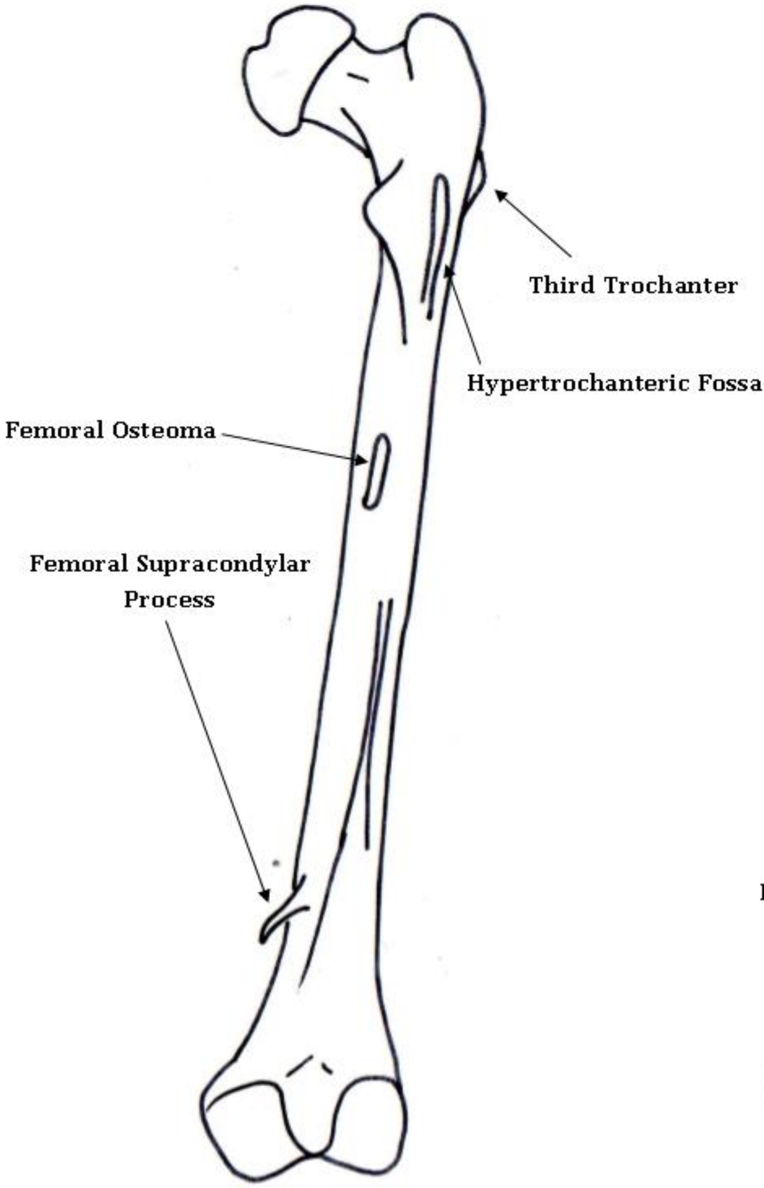
Superior View of Atlas



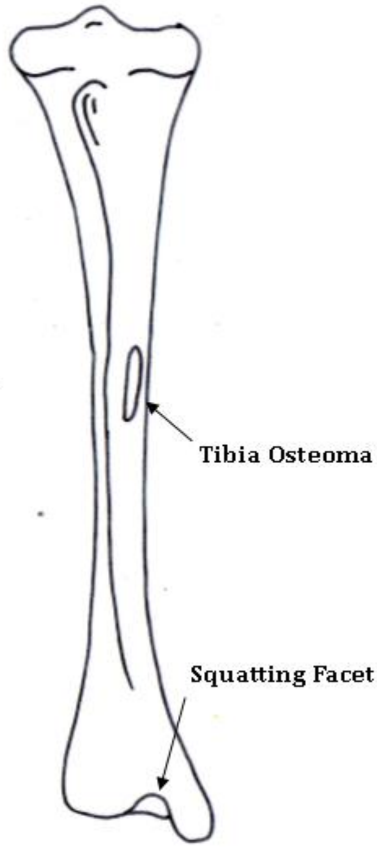
Superior View of Atlas



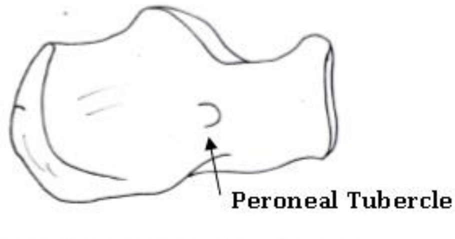
Superior View of Atlas



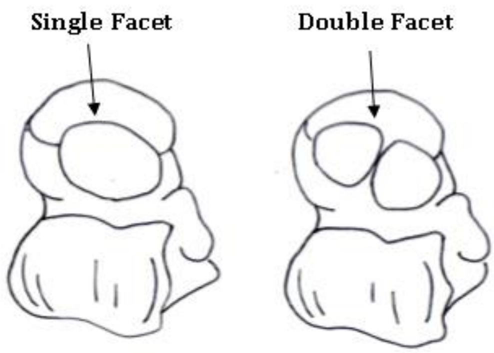
Right Posterior View of Femur



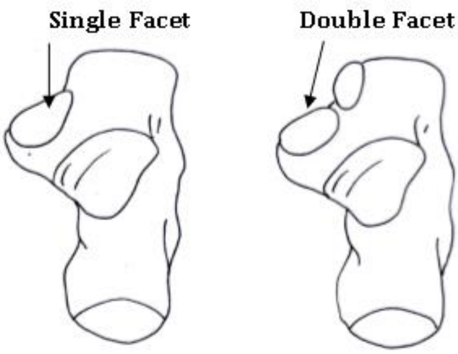
Right Anterior View of Tibia



Right Lateral View of Calcaneus



Right Inferior View of Talus



Right Superior View of Calcaneus

3 Inventory Form

Skeleton Number: 497 **Year of Excavation:** 10 **Skeleton Context:** 2125 **Trench No:** 1 **Date:** 27/11/12

Skeletal Inventory:

P = Present. A = Absent.

Cranial:

Bone:	L	M	R	Bone:	L	M	R
Frontal	....	P	....	Sphenoid	....	P	....
Parietal	P	....	P	Lacrimal	P	....	P
Occipital	....	P	....	Ethmoid	....	P	....
Temporal	P	....	P	Vomer	....	P	....
Zygomatic	P	....	P	Nasal	P	....	P
Maxilla	P	....	P	I.N.C.	P	....	P
Palatine	P	....	P	Hyoid	....	P	....
Mandible	....	P	....	Thyroid	....	A	....

Postcranial:

Bone:		L	M	R	Bone:	L	M	R
Sacrum	S1	....	P	....	Scapula	P	....	P
	S2	....	P	....	Clavicle	P	....	P
	S3	....	P	....	Manubrium	....	P	....
	S4	....	P	....	Sternal Body	....	P	....
	S5	....	P	....	Xiphoid	....	P	....
	Coccyx	....	P	....	Patella	P	....	P
Os Coxae	Ilium	P	....	P	1st Rib	P	....	P
	Ischium	P	....	P	2nd Rib	P	....	P
	Pubis	P	....	P	3rd to 12th Rib	10 (of 10)		10 (of 10)
	Acetabulum	P	....	P				
	Auric. Surface	P	....	P				

Comments:

Carla Burrell. Student Number: 383791.

Skeleton Number: 497 **Year of Excavation:** 10 **Skeleton Context:** 2125 **Trench No:** I **Date:** 27/11/12

Vertebrae:

Bone:	Centrum	Neural Arch	Dens	Anterior Arch
C1	P	P	………	P
C2	P	P	P	P

Bone:	Centrum	Neural Arch	Bone:	Centrum	Neural Arch
C3	P	P	T7	P	A
C4	P	P	T8	P	P
C5	P	P	T9	P	P
C6	P	P	T10	P	P
C7	P	P	T11	P	P
T1	P	P	T12	P	P
T2	P	P	L1	P	P
T3	P	A	L2	P	P
T4	P	P	L3	P	P
T5	P	P	L4	P	P
T6	P	P	L5	P	P

Long Bones:

Left Bone:	Prox. Epi.	Prox. 3rd	Med. 3rd	Dis 3rd	Dis. Epi.
Humerus	………	P	P	P	………
Ulna	………	P	P	P	………
Radius	………	P	P	P	………
Femur	………	P	P	P	………
Tibia	………	P	P	P	………
Fibula	………	P	P	P	………

Comments: left and right fibula can not be used for metrics

Carla Burrell. Student Number: 383791.

Skeleton Number: 497 **Year of Excavation:** 10 **Skeleton Context:** 2125 **Trench No:** I **Date:** 27/11/12

Right Bone:	Prox. Epi.	Prox. 3rd	Med. 3rd	Dis 3rd	Dis. Epi.
Humerus	………	P	P	P	………
Ulna	………	P	P	P	………
Radius	………	P	P	P	………
Femur	………	P	P	P	………
Tibia	………	P	P	P	………
Fibula	………	P	P	P	………

Extremities:

Bone:		L	R	Bone:		L	R
Scaphoid		P	P	Calcaneus		P	P
Lunate		P	P	Talus		P	P
Hamate		P	P	Cuboid		P	P
Capitate		P	P	Navicular		P	P
Pisiform		P	A	Medial Cuneiform		P	P
Triquetral		P	P	Intermediate Cuneiform		P	P
Trapezium		P	P	Lateral Cuneiform		P	P
Trapezoid		P	P	Metatarsals	1st	P	P
Metacarpals	1st	P	P		2nd	P	P
	2nd	P	P		3rd	P	P
	3rd	P	P		4th	P	P
	4th	P	P		5th	P	P
	5th	P	P	Proximal Phalanges		5	5
Proximal Phalanges		5	5	Medial Phalanges		2	4
Medial Phalanges		3	4	Distal Phalanges		3	3
Distal Phalanges		2	5	Sesamoids		2	0
Sesamoids		0	0				

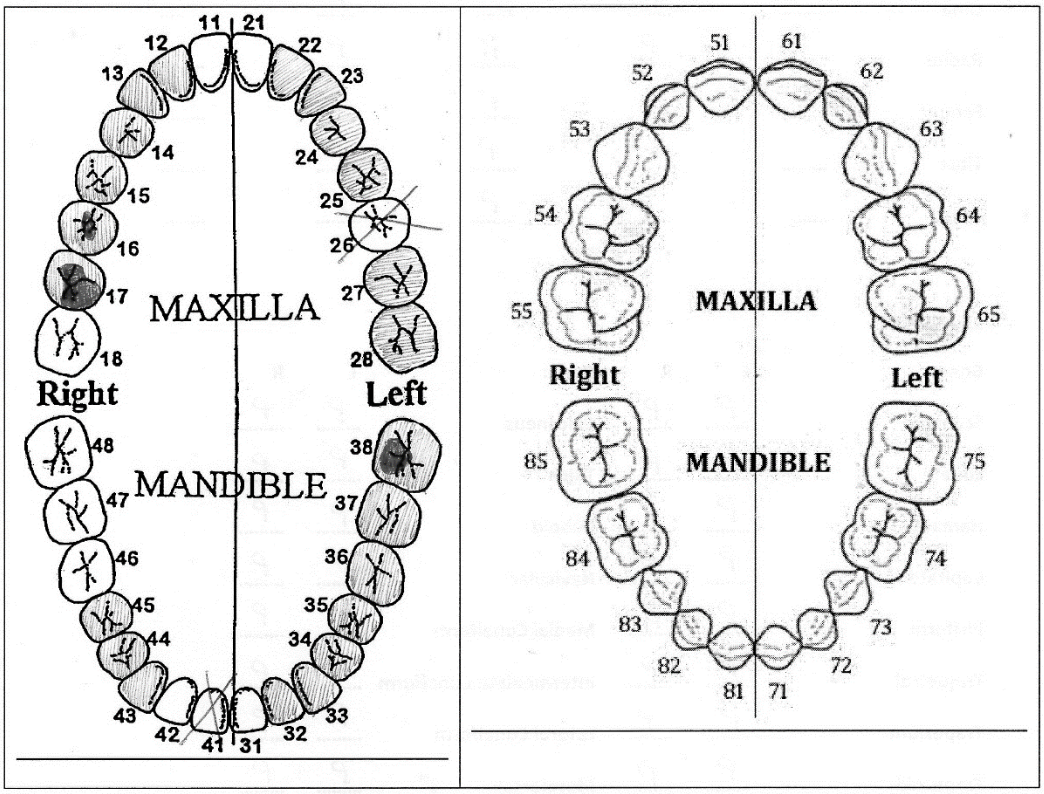
Comments:

Carla Burrell. Student Number: 383791.

Skeleton Number: 497 **Year of Excavation:** 10 **Skeleton Context:** 2125 **Trench No:** I **Date:** 27/11/12

Dentition:

Coloured = Present. Blank = Absent/Post-mortem loss. Cross stroke = Absent/Ante-mortem loss.



Comments:

Possible Abcess at 36 and 38

Abnormalities:

healed fracture of the right clavical, right ribs (3-8)
femoral eversion, left side
Partial Metopic Suture
Supraorbital notch, right side
Supraorbital foramen, left side
Saggittal crest
Occipital bun

2 x ossicles on left lambdoid
1x ossicle at right asterion
OA is evident.
T7 + T8 are fused.
Partial Agenisis of L5 arch. (left side) open
Double calcaneal facets, left and right.

Percentage of Skeleton; 77.5%

Photographs taken: Yes

Radiographs taken: Yes

Carla Burrell. Student Number: 383791.

4 Post-excavation Form

Skeleton Number: 497 **Year of Excavation:** 10 **Skeleton Context:** 2125 **Trench No:** I **Date:** 27/11/12

General:

Adult ✓ **Subadult** ....

MNI: 1 **Comments:**

Sex Estimation :

0 = Undetermined Sex. 1 = Female. 2 = Probable Female. 3 = Ambiguous Sex. 4 = Probable Male. 5 = Male.

Pelvis:	L	R
Greater Sciatic Notch	5	5
Subpubic Angle	5	5
Pre auricular Sulcus	5	1
Ventral Arc	2	2
Subpubic Concavity	5	5
Ischiopubic Ramus Ridge	5	5

Skull:	L	M	R
Nuchal Crest	....	5	....
Mastoid Process	5	....	5
Supra-Orbital Margin	....	....	....
Glabella	....	5	....
Mental Eminence	....	4	....

Humeral Head (mm):	L	R
Females <43mm	....	....
Indeterminate 43-47mm	....	....
Male >47mm	50	49

Femoral Head (mm):	L	R
Female <43.5mm	....	....
Indeterminate 43.5-46.5mm	....	....
Male >46.5mm	52	52

Overall Estimation: Male **Comments:**

Age Estimation:

Overall Development of Dentition 21+ **+/-** ....

Dental Attrition 45+

Pubic Symphysis	L	R
Phase	5	5
Age	27-66	27-66

Auricular Surface	L	R
Phase	6	7
Age	45-49	50-59

Carla Burrell. Student Number: 383791.

Skeleton Number: 497 Year of Excavation: 10 Skeleton Context: 2125 Trench No: I Date: 27/11/12

For Immature remains - Stage of Union:

0 = Unobservable. 1 = open. 2 = Partial Union. 3 = Complete Union.

Epiphyseal Fusion:

Bone:	Epiphysis:	L	R	Bone:	Epiphysis:	L	R
Scapula	Coracoid	………	………	Os Coxae	Illiac Crest	………	……
	Acromion	………	………		Triradiate	………	……
Clavical	Sternal	………	………		Ischiopubic Ramus	………	……
Humerus	Head	………	………	Femur	Head	………	……
	Distal	………	………		Greater Trochanter	………	……
	Distal Epicondyle	………	………		Distal	………	……
Radius	Proximal	………	………	Tibia	Proximal	………	……
	Distal	………	………		Distal	………	……
Ulna	Proximal	………	………	Fibula	Proximal	………	……
	Distal	………	………		Distal	………	……

Primary Ossification Centres:

Bone:	Area of Union:	Stage of Union:
Cervical Vertebrae	Neural arches to each other	………
	Neural arches to centrum	………
Thoracic Vertebrae	Neural arches to each other	………
	Neural arches to centrum	………
Lumbar Vertebrae	Neural arches to each other	………
	Neural arches to centrum	………

Overall Estimation: 45 to 49 **Comments:** Based on auricular surface.

Carla Burrell. Student Number: 383791.

Skeleton Number: 497 **Year of Excavation:** 10 **Skeleton Context:** 2125 **Trench No:** I **Date:** 27/11/12

Stature Estimation:

Left Bone:	Length (cm):	Pieces:	Epi/Di:	Age:
Humerus	38.2	1	Ep.	....
Ulna	29.9	1	Ep.	....
Radius	27.9	1	Ep.	....
Femur	52.8	1	Ep.	....
Tibia	43.2	1	Ep.	....
Fibula	....	....	....	....

Right Bone:	Length (cm):	Pieces:	Epi/Di:	Age:
Humerus	38.0	1	Ep.	....
Ulna	29.8	3	Ep.	....
Radius	27.5	2	Ep.	....
Femur	50.7	2	Ep.	....
Tibia	42.5	1	Ep.	....
Fibula	....	....	Ep.	....

Estimated Stature: 156.3 cm +/- 3.0 cm. 6 ft 1.3 in.

Comments: Measured twice. Abnormality to left leg; especially femur

Abnormalities:
See inventory.

Photographs taken: Yes

Radiographs taken: Yes

Carla Burrell. Student Number: 383791.

5 Poulton Chapel NMT Frequencies

n=Total Number of Traits, N=Total Number of Elements for which the Trait can be recorded, *No Left/Right Side Distinguished

	Non-adults						Males						Females					
	Left			Right			Left			Right			Left			Right		
Skeletal Variant	**n**	**N**	**%**	**n**	**N**	**%**	**n**	**N**	**%**	**n**	**N**	**%**	**n**	**N**	**%**	**n**	**N**	**%**
Metopism*	46	199	23.1				66	112	58.9				64	125	51.2			
Supraorbital Foramen	21	198	10.6	22	195	11.3	26	111	23.4	29	111	26.1	35	125	28.0	37	125	29.6
Supraorbital Notch	75	198	37.9	80	195	41.0	54	111	48.6	56	111	50.5	66	125	52.8	72	125	57.6
Frontal Foramen	4	31	12.9	1	28	3.6	1	11	9.1	0	10	0.0	2	9	22.2	1	8	12.5
Zygomaticofacial Foramen	20	142	14.1	18	139	12.9	11	96	11.5	11	100	11.0	8	116	6.9	9	114	7.9
Accessory Infraorbital Foramen	22	165	13.3	23	159	14.5	8	95	8.4	10	100	10.0	8	120	6.7	6	117	5.1
Frontal Button Osteoma*	0	198	0.0				3	113	2.7				3	127	2.4			
Frontal Bun*	0	198	0.0				0	113	0.0				0	127	0.0			
Frontal Temporal Articulation	0	198	0.0	0	198	0.0	0	113	0.0	0	113	0.0	0	127	0.0	0	127	0.0
Bregmatic Ossicle*	0	206	0.0				0	114	0.0				2	130	1.5			
Coronal Ossicle	0	211	0.0	0	216	0.0	1	117	0.9	1	115	0.9	0	131	0.0	0	132	0.0
Coronal Button Osteoma	0	211	0.0	0	216	0.0	0	117	0.0	0	115	0.0	1	131	0.8	0	132	0.0
Parietal Button Osteoma	0	215	0.0	0	219	0.0	1	118	0.8	0	116	0.0	2	132	1.5	1	134	0.7
Parietal Foramen	23	216	10.6	17	221	7.7	30	119	25.2	27	117	23.1	26	132	19.7	33	136	24.3
Auditory Torus	11	198	5.6	11	196	5.6	9	111	8.1	10	113	8.8	10	128	7.8	9	126	7.1
Mastoid Foramen	2	198	1.0	2	196	1.0	4	112	3.6	3	113	2.7	3	128	2.3	3	126	2.4
Sagittal Foramen*	0	210	0.0				1	116	0.9				0	132	0.0			
Sagittal Ossicle*	3	210	1.4				1	116	0.9				0	132	0.0			
Sagittal Bun*	0	210	0.0				5	116	4.3				1	132	0.8			
Sagittal Depression*	0	210	0.0				0	116	0.0				3	132	2.3			
Epipteric Ossicle	0	208	0.0	1	210	0.5	1	116	0.9	0	116	0.0	1	131	0.8	1	133	0.8

Continued...

Parietal Notch Ossicle	4	208	1.9	3	210	1.4	4	116	3.4	3	115	2.6	3	131	2.3	2	133	1.5
Asterion Ossicle	2	208	1.0	4	210	1.9	5	116	4.3	5	116	4.3	3	131	2.3	3	133	2.3
Highest Nuchal line*	0	213	0.0				0	116	0.0				0	136	0.0			
Ossicle at Lambda*	8	216	3.7				10	114	8.8				8	136	5.9			
Lambdoid Ossicle	24	216	11.1	27	217	12.4	22	115	19.1	19	114	16.7	21	136	15.4	24	136	17.6
Occipital Bun*	18	216	8.3				38	115	33.0				39	136	28.7			
Occipital Foramen*	0	216	0.0				0	114	0.0				2	136	1.5			
Pars Basilaris Depression*	1	190	0.5				0	110	0.0				0	121	0.0			
Precondylar Tubercle*	1	190	0.5				0	110	0.0				1	121	0.8			
Occipital Osteoma *	1	214	0.5				0	113	0.0				3	136	2.2			
Huschke Foramen	0	4	0.0	0	4	0.0	2	3	66.7	2	3	66.7	2	3	66.7	2	3	66.7
Posterior Condylar Canal	27	27	100.0	27	27	100.0	19	19	100.0	19	19	100.0	25	25	100.0	25	25	100.0
Occipital Condylar Facet	27	27	100.0	29	29	100.0	19	19	100.0	21	21	100.0	25	25	100.0	25	25	100.0
Anterior Condylar Canal	3	27	11.1	4	30	13.3	0	19	0.0	1	22	4.5	1	25	4.0	1	26	3.8
Foramen Ovale	0	27	0.0	0	27	0.0	0	19	0.0	0	19	0.0	0	25	0.0	0	25	0.0
Foramen Spinosum Open	0	27	0.0	0	27	0.0	0	19	0.0	0	19	0.0	0	25	0.0	1	25	4.0
Accessory Lesser Palatine Foramen	135	135	100.0	135	135	100.0	76	76	100.0	76	76	100.0	96	96	100.0	96	96	100.0
Palatine Torus*	0	135	0.0				0	76	0.0				0	96	0.0			
Maxillary Torus	0	152	0.0	0	146	0.0	1	80	1.3	1	86	1.2	1	105	1.0	0	103	0.0
Mandibular Torus	0	202	0.0	0	203	0.0	3	118	2.5	3	120	2.5	0	131	0.0	1	130	0.8
Carabelli's Cusp Maxillary Deciduous 1st Molar	17	72	23.6	23	76	30.3	0	2	0.0	0	2	0.0	0	2	0.0	0	2	0.0
Carabelli's Cusp Mandibular Deciduos 1st Molar	98	110	89.1	92	106	86.8	0	2	0.0	0	2	0.0	0	2	0.0	0	2	0.0
Carabelli's Cusp Maxillary Permanent 1st Molar	25	97	25.8	31	100	31.0	1	25	4.0	1	25	4.0	1	46	2.2	1	42	2.4
Carabelli's Cusp Mandibular Permanent 1st Molar	115	134	85.8	101	124	81.5	25	43	58.1	28	45	62.2	21	39	53.8	21	42	50.0
Sixth Cusp Mandibular Permanent 2nd Molar	2	64	3.1	2	58	3.4	1	39	2.6	1	39	2.6	0	30	0.0	0	34	0.0
Maxillary Third Molar	26	32	81.3	33	37	89.2	47	55	85.5	52	58	89.7	64	75	85.3	56	70	80.0
Mandibular Third Molar	39	45	86.7	34	43	79.1	75	89	84.3	82	92	89.1	68	82	82.9	71	86	82.6

Continued…

Peg Tooth*	1	203	0.5				3	115	2.6				7	137	5.1			
Shovel Shaped Incisors*	12	203	5.9				2	116	1.7				2	137	1.5			
Congenital Absence of Dentition*	1	203	0.5				1	116	0.9				1	137	0.7			
Supernumerary Dentition*	1	203	0.5				1	116	0.9				0	137	0.0			
Talan Cusp*	1	203	0.5				0	116	0.0				1	136	0.7			
Late Eruption of Canines*	0	203	0.0				1	117	0.9				0	136	0.0			
Enamel Pearls*	0	203	0.0				0	117	0.0				0	136	0.0			
Suprascapular Foramen	0	203	0.0	0	184	0.0	2	124	1.6	0	117	0.0	5	128	3.9	2	126	1.6
Acromial Articular Facet	0	203	0.0	0	185	0.0	0	124	0.0	0	116	0.0	0	128	0.0	0	126	0.0
Accessory Clavicle Facet	3	187	1.6	4	168	2.4	9	121	7.4	11	117	9.4	11	129	8.5	9	123	7.3
Sternal Aperture*	0	68	0.0				1	34	2.9				0	41	0.0			
Humeral Supracondylar Process	1	199	0.5	0	188	0.0	1	120	0.8	1	115	0.9	2	130	1.5	1	125	0.8
Humeral Septal Aperture	5	197	2.5	7	187	3.7	6	120	5.0	3	115	2.6	16	130	12.3	11	125	8.8
Humeral Osteoma	0	197	0.0	0	187	0.0	0	120	0.0	0	115	0.0	0	130	0.0	0	125	0.0
Proximal Phalanx Osteoma	0	197	0.0	0	199	0.0	0	120	0.0	0	122	0.0	0	130	0.0	1	128	0.8
Single Atlas Articulating Facet	114	165	89.1	150	165	90.9	81	106	76.4	81	106	76.4	100	117	85.5	102	118	86.4
Double Atlas Articulating Facet	18	165	10.9	16	165	9.1	25	106	25.6	25	106	23.6	17	117	14.5	16	118	13.6
Occipitocervical Cranial Border Shift*	0	169	0.0				1	108	0.9				0	117	0.0			
Bifurcation of C1 Neural Arch*	0	169	0.0				2	108	1.9				0	117	0.0			
Clefting of C1 Neural Arch*	0	169	0.0				2	108	1.9				2	117	1.7			
Bifurcation of C1 Anterior Neural Arch*	1	167	0.6				0	108	0.0				0	116	0.0			
Block Fusion of C2 and C3*	0	181	0.0				7	110	6.4				1	117	0.9			
Block Fusion of C3 and C4*	0	181	0.0				0	110	0.0				0	117	0.0			
Block Fusion of C4 and C5 *	0	181	0.0				0	110	0.0				0	117	0.0			
Block Fusion of C5 and C6*	0	183	0.0				0	111	0.0				0	120	0.0			
Block Fusion of C6 and C7 *	0	174	0.0				3	110	2.7				0	119	0.0			
Block Fusion of C7 and T1*	0	174	0.0				0	110	0.0				0	119	0.0			
Cervicothoracic Cranial Border Shift*	0	174	0.0				0	110	0.0				0	119	0.0			

Continued…

Extra Thoracic Vertebrae*	0	182	0.0				2	114	1.8				0	126	0.0			
Thirteenth Rib	0	195	0.0	0	195	0.0	2	116	1.7	2	116	1.7	0	129	0.0	0	129	0.0
Bifid Rib	0	195	0.0	0	195	0.0	0	116	0.0	0	116	0.0	0	129	0.0	0	129	0.0
Flared Rib	0	195	0.0	0	195	0.0	0	116	0.0	0	116	0.0	0	129	0.0	0	129	0.0
Congenital Absence of Thoracic Vertebrae*	0	180	0.0				0	114	0.0				1	126	0.8			
Block Fusion of T7 and T8*	0	179	0.0				2	115	1.7				0	126	0.0			
Block Fusion of T8 and T9*	0	179	0.0				1	115	0.9				1	126	0.8			
Block Fusion of T9 and T10*	0	179	0.0				2	115	1.7				0	126	0.0			
Block Fusion of T10 and T11*	0	179	0.0				0	115	0.0				1	126	0.8			
Thoracolumbar Border Caudal Shift*	2	179	1.1				0	115	0.0				0	127	0.0			
Lumbarisation of S1	1	179	0.6				0	111	0.0				1	128	0.8			
Block Fusion of L1 and L2*	0	193	0.0				0	117	0.0				1	136	0.7			
Spondylolysis of L4 Neural Arch*	0	179	0.0				0	110	0.0				1	128	0.8			
Spondylolysis of L5 Neural Arch*	2	180	1.1				2	110	1.8				5	130	3.8			
Bifurcation of L5 Neural Arch*	2	180	1.1				0	110	0.0				1	130	0.8			
Clefting of L5 Neural Arch*	2	180	1.1				0	110	0.0				0	130	0.0			
Extra Lumbar Vertebrae*	8	180	4.4				8	109	7.3				4	129	3.1			
Lumbarisation of L6	4	8	50.0				1	8	12.5				0	4	0.0			
Sacralisation of L6*	0	8	0.0				0	8	0.0				0	4	0.0			
Spondylolysis of L6 Arch*	0	8	0.0				1	8	12.5				0	4	0.0			
Bifurcation of L6 Neural Arch*	0	8	0.0				0	8	0.0				0	4	0.0			
Clefting of L6 Neural Arch*	0	8	0.0				0	8	0.0				0	4	0.0			
Accessory Lumbar Facet*	3	178	1.7				1	107	0.9				0	125	0.0			
Bifurcation of S1 Neural Arch*	6	184	3.3				3	111	2.7				0	128	0.0			
Clefting of S1 Neural Arch*	1	184	0.5				4	111	3.6				2	128	1.6			
Bifurcation of S2 Neural Arch*	0	184	0.0				0	111	0.0				0	128	0.0			
Clefting of S2 Neural Arch*	2	169	1.2				1	105	1.0				2	127	1.6			
Spina Bifida Occulta *	7	186	3.8				13	110	11.8				12	128	9.4			

Continued...

Accessory Sacral Facet	0	199	0.0	0	198	0.0	14	121	11.6	17	118	14.4	22	136	16.2	23	134	17.2
Ilium Foramen	36	199	18.1	37	198	18.7	21	122	17.2	24	120	20.0	21	136	15.4	22	134	16.4
Sacroiliac Joint Fusion	1	199	0.5	1	199	0.5	2	120	1.7	0	118	0.0	0	136	0.0	0	134	0.0
Acetabular Crease	1	189	0.5	1	186	0.5	0	120	0.0	0	115	0.0	0	134	0.0	0	130	0.0
Femoral Osteoma	0	208	0.0	0	207	0.0	2	120	1.7	0	123	0.0	1	136	0.7	0	132	0.0
Femoral Supracondylar Process	0	208	0.0	0	207	0.0	0	120	0.0	0	123	0.0	1	137	0.7	0	132	0.0
Femoral Anteversion	1	209	0.5	1	207	0.5	3	120	2.5	1	123	0.8	5	135	3.7	3	132	2.3
Allen's Fossa	0	207	0.0	0	205	0.0	6	116	5.2	11	121	9.1	8	134	6.0	8	130	6.2
Poirier's Facet	0	207	0.0	0	205	0.0	3	116	2.6	3	121	2.5	0	134	0.0	1	130	0.8
Plaque Formation	0	207	0.0	0	205	0.0	14	116	12.1	14	121	11.6	12	134	9.0	13	130	10.0
Hypertrochanteric Fossa	7	209	3.3	4	206	1.9	42	119	35.3	43	122	35.2	48	134	35.8	49	132	37.1
Third Trochanter	33	209	15.8	32	206	15.5	31	118	26.3	28	122	23.0	43	135	31.9	43	132	32.6
Vastus Notch	2	116	1.7	3	112	2.7	16	107	15.0	19	110	17.3	13	122	10.7	13	117	11.1
Tibia Anteversion	1	209	0.5	1	209	0.5	1	117	0.9	1	116	0.9	1	133	0.8	1	130	0.8
Tibia Osteoma	0	209	0.0	0	209	0.0	0	117	0.0	0	116	0.0	1	133	0.8	0	130	0.0
Squatting Facet	32	197	16.2	32	196	16.3	59	113	52.2	62	113	54.9	83	133	62.4	80	130	61.5
Inferior Talus Single Articular Facet	115	148	77.7	115	145	79.3	59	108	54.6	61	109	56	84	125	67.2	89	127	70.1
Inferior Talus Double Articular Facet	37	148	22.3	30	145	20.7	49	108	45.4	48	109	44	41	125	32.8	41	127	29.9
Single Calcaneal Articular Facet	118	152	77.6	122	154	79.2	56	109	51.4	62	111	55.9	88	130	67.7	90	129	69.8
Double Calcaneal Articular Facet	34	152	22.4	32	154	20.8	53	109	48.6	49	111	44.1	42	130	32.3	39	129	30.2
Peroneal Tubercle	10	159	6.3	9	158	5.7	39	110	35.5	39	110	35.5	27	130	20.8	30	129	23.3
Metatarsal Osteoma	0	159	0.0	0	158	0.0	0	110	0.0	0	110	0.0	0	130	0.0	0	129	0.0

6 St. Owen's Church NMT Frequencies

n=Total Number of Traits, N=Total Number of Elements for which the Trait can be recorded, *No Left/Right Side Distinguished

	Non-adults						Males						Females					
	Left			Right			Left			Right			Left			Right		
Traits	**n**	**N**	**%**	**n**	**N**	**%**	**n**	**N**	**%**	**n**	**N**	**%**	**n**	**N**	**%**	**n**	**N**	**%**
Metopism*	16	42	38.1				25	37	67.6				19	36	52.8			
Supraorbital Foramen	14	39	35.9	16	36	44.4	13	34	38.2	13	35	37.1	15	34	44.1	16	33	48.5
Supraorbital Notch	22	39	56.4	20	36	55.6	23	34	67.6	22	35	62.9	22	34	64.7	20	33	60.6
Frontal Foramen	5	32	15.6	6	33	18.2	12	41	29.3	12	44	27.3	5	37	13.5	4	38	10.5
Zygomaticofacial Foramen	21	29	72.4	28	34	82.4	18	26	69.2	23	29	79.3	19	29	65.5	19	32	59.4
Accessory Infraorbital Foramen	15	35	42.9	14	30	46.7	14	31	45.2	13	30	43.3	15	27	55.6	15	28	53.6
Frontal Button Osteoma*	1	43	2.3				3	38	7.9				4	36	11.1			
Frontal Bun*	0	47	0.0				0	61	0.0				0	53	0.0			
Frontal Temporal Articulation	0	34	0.0	0	32	0.0	0	46	0.0	0	47	0.0	0	29	0.0	0	27	0.0
Bregmatic Ossicle*	0	41	0.0				0	36	0.0				0	35	0.0			
Coronal Ossicle	1	40	2.5	0	40	0.0	0	35	0.0	0	37	0.0	0	35	0.0	0	35	0.0
Coronal Button Osteoma	0	40	0.0	0	40	0.0	0	35	0.0	0	37	0.0	1	35	2.9	0	35	0.0
Parietal Button Osteoma	1	44	2.3	0	45	0.0	1	41	2.4	0	41	0.0	0	37	0.0	0	39	0.0
Parietal Foramen	12	44	27.3	10	45	22.2	12	41	29.3	10	41	24.4	11	38	28.9	12	39	30.8
Auditory Torus	20	43	46.5	16	36	44.4	31	49	63.3	30	47	63.8	32	46	69.6	33	45	73.3
Mastoid Foramen	5	41	12.2	5	34	14.7	19	49	38.8	22	47	46.8	15	45	33.3	14	44	31.8
Sagittal Foramen*	0	44	0.0				2	49	4.1				0	44	0.0			
Sagittal Ossicle*	1	44	2.3				3	49	6.1				1	44	2.3			
Sagittal Bun*	1	44	2.3				1	49	2.0				0	44	0.0			
Sagittal Depression*	0	44	0.0				2	49	4.1				1	44	2.3			
Epipteric Ossicle	0	42	0.0	0	42	0.0	1	49	2.0	0	48	0.0	0	43	0.0	0	44	0.0

Continued…

Parietal Notch Ossicle	1	44	2.3	1	44	2.3	2	49	4.1	0	47	0.0	1	43	2.3	1	44	2.3
Asterion Ossicle	1	44	2.3	1	44	2.3	3	49	6.1	1	48	2.1	2	44	4.5	1	45	2.2
Highest Nuchal line*	1	45	2.2				0	48	0.0				0	46	0.0			
Ossicle at Lambda*	4	49	8.2				6	50	12.0				7	47	14.9			
Lambdoid Ossicle	4	50	8.0	6	50	12.0	9	49	18.4	14	50	28.0	7	46	15.2	9	47	19.1
Occipital Bun*	21	46	45.7				13	39	33.3				24	40	60.0			
Occipital Foramen*	3	46	6.5				4	38	10.5				5	40	12.5			
Pars Basilaris Depression*	2	33	6.1				3	27	11.1				2	32	6.3			
Precondylar Tubercle*	0	16	0.0				0	20	0.0				0	20	0.0			
Occipital Osteoma *	0	45	0.0				3	36	8.3				0	39	0.0			
Huschke Foramen	4	6	66.7	4	6	66.7	3	10	30.0	3	10	30.0	8	13	61.5	8	13	61.5
Posterior Condylar Canal	0	16	0.0	1	7	14.3	2	26	7.7	0	8	0.0	0	20	0.0	0	13	0.0
Occipital Condylar Facet	30	30	100.0	27	27	100.0	31	31	100.0	23	23	100.0	26	26	100.0	28	28	100.0
Anterior Condylar Canal	2	7	28.6	0	19	0.0	0	5	0.0	1	21	4.8	0	8	0.0	0	27	0.0
Foramen Ovale	0	3	0.0	2	4	50.0	0	10	0.0	6	11	54.5	0	9	0.0	2	9	22.2
Foramen Spinosum Open	1	3	33.3	1	2	50.0	4	12	33.3	1	8	12.5	0	7	0.0	1	7	14.3
Accessory Lesser Palatine Foramen	1	36	2.8	2	37	5.4	0	49	0.0	12	55	21.8	1	48	2.1	4	49	8.2
Palatine Torus*	0	31	0.0				0	32	0.0				1	29	3.4			
Maxillary Torus	0	38	0.0	1	31	3.2	1	35	2.9	1	33	3.0	0	31	0.0	0	30	0.0
Mandibular Torus	1	40	2.5	1	42	2.4	1	38	2.6	1	38	2.6	2	38	5.3	0	35	0.0
Carabelli's Cusp Maxillary Deciduous 1st Molar	1	5	20.0	2	6	33.3	4	7	57.1	3	7	42.9	0	2	0.0	1	4	25.0
Carabelli's Cusp Mandibular Deciduos 1st Molar	9	9	100.0	10	10	100.0	10	10	100.0	11	12	91.7	3	5	60.0	3	4	75.0
Carabelli's Cusp Maxillary Permanent 1st Molar	0	9	0.0	0	9	0.0	8	17	47.1	4	15	26.7	1	16	6.3	1	18	5.6
Carabelli's Cusp Mandibular Permanent 1st Molar	8	12	66.7	9	14	64.3	12	20	60.0	16	25	64.0	11	24	45.8	11	21	52.4
Sixth Cusp Mandibular Permanent 2nd Molar	0	10	0.0	0	11	0.0	0	13	0.0	0	13	0.0	1	17	5.9	1	17	5.9
Maxillary Third Molar	11	15	73.3	14	18	77.8	16	19	84.2	19	21	90.5	17	21	81.0	20	23	87.0
Mandibular Third Molar	18	20	90.0	17	20	85.0	23	24	95.8	23	26	88.5	23	29	79.3	22	27	81.5

Continued...

Peg Tooth*	2	41	4.9				1	40	2.5				0	37	0.0			
Shovel Shaped Incisors*	0	41	0.0				1	40	2.5				0	36	0.0			
Congenital Absence of Dentition*	0	41	0.0				0	40	0.0				1	36	2.8			
Supernumerary Dentition*	0	41	0.0				0	40	0.0				1	36	2.8			
Talan Cusp*	0	41	0.0				0	40	0.0				0	36	0.0			
Late Eruption of Canines*	1	41	2.4				0	40	0.0				0	36	0.0			
Enamel Pearls*	0	41	0.0				0	42	0.0				1	38	2.6			
Suprascapular Foramen	2	46	4.3	3	50	6.0	1	47	2.1	1	49	2.0	0	47	0.0	0	43	0.0
Acromial Articular Facet	0	45	0.0	0	48	0.0	0	47	0.0	0	48	0.0	0	44	0.0	0	41	0.0
Accessory Clavicle Facet	7	39	17.9	7	42	16.7	11	46	23.9	9	43	20.9	6	41	14.6	7	37	18.9
Sternal Aperture*	0	27	0.0				1	27	3.7				0	21	0.0			
Humeral Supracondylar Process	3	45	6.7	3	47	6.4	3	52	5.8	1	41	2.4	0	36	0.0	1	39	2.6
Humeral Septal Aperture	4	46	8.7	2	46	4.3	2	51	3.9	3	41	7.3	3	35	8.6	2	39	5.1
Humeral Osteoma	0	48	0.0	0	53	0.0	0	54	0.0	0	48	0.0	2	38	5.3	0	46	0.0
Proximal Phalanx Osteoma	0	56	0.0	0	42	0.0	0	60	0.0	0	49	0.0	0	47	0.0	0	40	0.0
Single Atlas Articulating Facet	29	34	85.3	23	29	79.3	27	29	93.1	20	24	83.3	27	33	81.8	24	31	77.4
Double Atlas Articulating Facet	5	34	14.7	6	29	20.7	2	29	6.9	4	24	16.7	6	33	18.2	7	31	22.6
Occipitocervical Cranial Border Shift*	0	35	0.0				0	34	0.0				0	36	0.0			
Bifurcation of C1 Neural Arch*	0	33	0.0				0	31	0.0				0	34	0.0			
Clefting of C1 Neural Arch*	0	33	0.0				0	31	0.0				0	34	0.0			
Bifurcation of C1 Anterior Neural Arch*	0	33	0.0				0	31	0.0				0	34	0.0			
Block Fusion of C2 and C3*	0	42	0.0				0	40	0.0				0	38	0.0			
Block Fusion of C3 and C4*	0	45	0.0				0	56	0.0				0	44	0.0			
Block Fusion of C4 and C5 *	0	29	0.0				0	33	0.0				0	28	0.0			
Block Fusion of C5 and C6*	0	40	0.0				1	44	2.3				0	38	0.0			
Block Fusion of C6 and C7 *	0	40	0.0				0	45	0.0				0	38	0.0			
Block Fusion of C7 and T1*	0	40	0.0				0	45	0.0				0	38	0.0			
Cervicothoracic Cranial Border Shift*	0	42	0.0				0	46	0.0				1	37	2.7			

Continued…

Extra Thoracic Vertebrae*	0	41	0.0				0	51	0.0				1	38	2.6			
Thirteenth Rib	0	11	0.0	0	11	0.0	0	16	0.0	0	16	0.0	1	11	9.1	1	11	9.1
Bifid Rib	0	16	0.0	0	16	0.0	2	13	15.4	2	13	15.4	0	13	0.0	0	13	0.0
Flared Rib	1	60	1.7	0	16	0.0	0	74	0.0	2	16	12.5	0	59	0.0	1	13	7.7
Congenital Absence of Thoracic Vertebrae*	0	45	0.0				0	56	0.0				0	42	0.0			
Block Fusion of T7 and T8*	0	47	0.0				1	56	1.8				0	47	0.0			
Block Fusion of T8 and T9*	0	47	0.0				1	56	1.8				0	47	0.0			
Block Fusion of T9 and T10*	0	47	0.0				1	56	1.8				0	47	0.0			
Block Fusion of T10 and T11*	0	47	0.0				0	58	0.0				0	46	0.0			
Thoracolumbar Border Caudal Shift*	0	46	0.0				0	55	0.0				1	42	2.4			
Lumbarisation of S1	2	46	4.3				3	52	5.8				4	44	9.1			
Block Fusion of L1 and L2*	1	79	1.3				0	86	0.0				0	70	0.0			
Spondylolysis of L4 Neural Arch*	1	47	2.1				0	50	0.0				0	44	0.0			
Spondylolysis of L5 Neural Arch*	4	49	8.2				1	48	2.1				0	40	0.0			
Bifurcation of L5 Neural Arch*	1	49	2.0				2	48	4.2				0	40	0.0			
Clefting of L5 Neural Arch*	0	49	0.0				0	48	0.0				0	40	0.0			
Extra Lumbar Vertebrae*	0	48	0.0				1	51	2.0				0	43	0.0			
Lumbarisation of L6	0	2	0.0				0	2	0.0				0	1	0.0			
Sacralisation of L6*	0	2	0.0				0	2	0.0				0	0	0.0			
Spondylolysis of L6 Arch*	0	2	0.0				0	2	0.0				0	0	0.0			
Bifurcation of L6 Neural Arch*	0	2	0.0				0	2	0.0				0	0	0.0			
Clefting of L6 Neural Arch*	1	13	7.7				1	18	5.6				0	9	0.0			
Accessory Lumbar Facet*	0	46	0.0				0	49	0.0				0	39	0.0			
Bifurcation of S1 Neural Arch*	4	44	9.1				6	47	12.8				5	42	11.9			
Clefting of S1 Neural Arch*	0	44	0.0				3	47	6.4				0	42	0.0			
Bifurcation of S2 Neural Arch*	1	40	2.5				0	46	0.0				1	40	2.5			
Clefting of S2 Neural Arch*	1	40	2.5				1	46	2.2				0	40	0.0			
Spina Bifida Occulta *	9	42	21.4				11	47	23.4				16	42	38.1			

Continued…

Accessory Sacral Facet	3	59	5.1	3	62	4.8	17	63	27.0	19	59	32.2	27	58	46.6	25	50	50.0
Ilium Foramen	61	61	100.0	62	64	96.9	61	63	96.8	55	58	94.8	55	58	94.8	46	51	90.2
Sacroiliac Joint Fusion	1	61	1.6	1	63	1.6	2	63	3.2	1	58	1.7	1	58	1.7	1	51	2.0
Acetabular Crease	0	61	0.0	1	62	1.6	1	62	1.6	2	57	3.5	2	58	3.4	2	52	3.8
Femoral Osteoma	0	66	0.0	0	62	0.0	3	65	4.6	2	58	3.4	0	55	0.0	0	53	0.0
Femoral Supracondylar Process	0	62	0.0	1	62	1.6	1	65	1.5	1	59	1.7	0	54	0.0	0	52	0.0
Femoral Anteversion	0	65	0.0	0	63	0.0	0	65	0.0	0	59	0.0	0	54	0.0	0	51	0.0
Allen's Fossa	0	60	0.0	0	60	0.0	2	62	3.2	4	57	7.0	5	51	9.8	5	48	10.4
Poirier's Facet	0	60	0.0	0	60	0.0	5	62	8.1	5	57	8.8	2	51	3.9	1	48	2.1
Plaque Formation	1	60	1.7	1	60	1.7	8	62	12.9	7	58	12.1	8	51	15.7	5	48	10.4
Hypertrochanteric Fossa	6	61	9.8	7	62	11.3	40	63	63.5	37	58	63.8	34	52	65.4	34	49	69.4
Third Trochanter	12	61	19.7	11	61	18.0	19	63	30.2	16	58	27.6	13	52	25.0	15	49	30.6
Vastus Notch	0	14	0.0	0	13	0.0	5	39	12.8	4	35	11.4	5	37	13.5	5	33	15.2
Tibia Anteversion	0	55	0.0	0	60	0.0	0	50	0.0	0	49	0.0	0	48	0.0	1	47	2.1
Tibia Osteoma	0	55	0.0	0	60	0.0	1	50	2.0	0	49	0.0	0	49	0.0	0	47	0.0
Squatting Facet	10	29	34.5	12	32	37.5	10	40	25.0	12	40	30.0	14	39	35.9	18	38	47.4
Inferior Talus Single Articular Facet	5	18	27.8	10	21	47.6	10	33	30.3	10	34	29.4	12	28	42.9	10	27	37
Inferior Talus Double Articular Facet	13	18	72.2	11	21	52.4	23	33	69.7	24	34	70.6	16	28	57.1	17	27	63
Single Calcaneal Articular Facet	7	21	33.3	10	21	47.6	10	35	28.6	9	36	25	13	34	38.2	11	32	34.4
Double Calcaneal Articular Facet	14	21	66.7	11	21	52.4	25	35	71.4	27	36	75	21	34	61.8	21	32	65.6
Peroneal Tubercle	6	25	24.0	6	25	24.0	21	33	63.6	19	34	55.9	16	33	48.5	18	33	54.5
Metatarsal Osteoma	0	78	0.0	0	77	0.0	1	50	2.0	1	53	1.9	0	55	0.0	0	57	0.0

7 Results of the Kruskal-Wallis H Test for the St Owen's Church Non-adult Sample

Nonmetric Trait	Kruskal-Wallis H Results (χ^2)
Auditory Torus	$\chi^2(5) = 6.404$, p =0.041
Huschke Foramen	$\chi^2(5) = 10.493$, p =0.005
Thirteenth Rib	$\chi^2(5) = 15.185$, p =0.001
Vastus Notch	$\chi^2(5) = 45.251$, p =<0.001
Tibia Anteversion	$\chi^2(5) = 7.771$, p =0.021
Tibia Osteoma	$\chi^2(5) = 7.771$, p =0.021
Squatting Facet	$\chi^2(5) = 10.311$, p =0.006
Inferior Talus Single Articular Facet	$\chi^2(5) = 17.796$, p =<0.001
Single Calcaneal Articular Facet	$\chi^2(5) = 14.565$, p =0.001
Peroneal Tubercle	$\chi^2(5) = 11.110$, p =0.004
Metatarsal Osteoma	$\chi^2(5) = 6.858$, p =0.032

8 Norton Priory NMT Frequencies

n=Total Number of Traits, N=Total Number of Elements for which the Trait can be recorded, *No Left/Right Side Distinguished

	Non-adults						Males						Females					
	Left			Right			Left			Right			Left			Right		
Traits	**N**	**N**	**%**	**n**	**N**	**%**	**n**	**N**	**%**	**n**	**N**	**%**	**n**	**N**	**%**	**n**	**N**	**%**
Metopism*	1	11	9.1				29	56	51.8				5	19	26.3			
Supraorbital Foramen	3	11	27.3	2	9	22.2	22	51	43.1	27	56	48.2	8	19	42.1	7	19	36.8
Supraorbital Notch	4	11	36.4	3	9	33.3	26	51	51.0	25	56	44.6	8	19	42.1	9	20	45.0
Frontal Foramen	0	11	0.0	0	9	0.0	0	52	0.0	1	56	1.8	0	19	0.0	0	20	0.0
Zygomaticofacial Foramen	5	9	55.6	2	4	50.0	39	46	84.8	35	49	71.4	9	15	60.0	9	15	60.0
Accessory Infraorbital Foramen	4	8	50.0	2	7	28.6	23	38	60.5	22	38	57.9	6	15	40.0	6	15	40.0
Frontal Button Osteoma*	0	11	0.0				5	63	7.9				1	20	5.0			
Frontal Bun*	1	11	9.1				1	63	1.6				1	20	5.0			
Frontal Temporal Articulation	0	11	0.0	0	11	0.0	0	62	0.0	0	62	0.0	0	20	0.0	0	20	0.0
Bregmatic Ossicle*	0	10	0.0				2	64	3.1				0	20	0.0			
Coronal Ossicle	0	10	0.0	0	8	0.0	1	64	1.6	5	63	7.9	1	20	5.0	2	20	10.0
Coronal Button Osteoma	0	10	0.0	0	8	0.0	1	64	1.6	0	63	0.0	0	20	0.0	0	20	0.0
Parietal Button Osteoma	0	11	0.0	0	10	0.0	1	64	1.6	1	63	1.6	1	21	4.8	1	20	5.0
Parietal Foramen	2	11	18.2	2	10	20.0	29	64	45.3	23	63	36.5	7	21	33.3	7	20	35.0
Auditory Torus	3	9	33.3	2	8	25.0	37	56	66.1	37	55	67.3	8	20	40.0	8	19	42.1
Mastoid Foramen	1	9	11.1	2	8	25.0	24	55	43.6	25	54	46.3	5	20	25.0	5	19	26.3
Sagittal Foramen*	0	10	0.0				0	64	0.0				1	20	5.0			
Sagittal Ossicle*	0	10	0.0				0	64	0.0				0	20	0.0			
Sagittal Bun*	0	10	0.0				5	64	7.8				0	20	0.0			
Sagittal Depression*	0	10	0.0				0	64	0.0				1	20	5.0			
Epipteric Ossicle	1	10	10.0	0	10	0.0	1	64	1.6	2	64	3.1	0	20	0.0	1	20	5.0

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Parietal Notch Ossicle	1	10	10.0	0	10	0.0	0	64	0.0	1	64	1.6	0	21	0.0	0	20	0.0
Asterion Ossicle	1	10	10.0	0	10	0.0	5	64	7.8	7	64	10.9	1	21	4.8	2	20	10.0
Highest Nuchal line*	0	11	0.0				0	65	0.0				0	23	0.0			
Ossicle at Lambda*	2	10	20.0				8	65	12.3				4	23	17.4			
Lambdoid Ossicle	1	10	10.0	1	10	10.0	18	65	27.7	19	65	29.2	6	23	26.1	7	23	30.4
Occipital Bun*	1	11	9.1				22	65	33.8				8	23	34.8			
Occipital Foramen*	2	11	18.2				8	65	12.3				5	23	21.7			
Pars Basilaris Depression*	0	8	0.0				1	40	2.5				0	17	0.0			
Precondylar Tubercle*	0	8	0.0				2	40	5.0				0	17	0.0			
Occipital Osteoma *	0	11	0.0				1	60	1.7				0	21	0.0			
Huschke Foramen	0	0	0.0	0	0	0.0	4	17	23.5	5	17	29.4	3	10	30.0	3	10	30.0
Posterior Condylar Canal	0	7	0.0	0	7	0.0	0	38	0.0	0	38	0.0	0	17	0.0	0	17	0.0
Occipital Condylar Facet	3	3	100.0	4	4	100.0	25	25	100.0	24	24	100.0	7	7	100.0	7	7	100.0
Anterior Condylar Canal	0	4	0.0	0	4	0.0	1	34	2.9	1	34	2.9	0	14	0.0	0	14	0.0
Foramen Ovale	0	4	0.0	0	4	0.0	0	34	0.0	0	34	0.0	0	14	0.0	0	14	0.0
Foramen Spinosum Open	0	4	0.0	0	4	0.0	0	34	0.0	0	34	0.0	0	14	0.0	0	14	0.0
Accessory Lesser Palatine Foramen	0	6	0.0	0	6	0.0	2	44	4.5	2	44	4.5	0	17	0.0	0	17	0.0
Palatine Torus*	0	6	0.0				3	48	6.3				2	17	11.8			
Maxillary Torus	0	8	0.0	0	7	0.0	4	52	7.7	3	52	5.8	0	20	0.0	0	20	0.0
Mandibular Torus	0	10	0.0	0	9	0.0	4	61	6.6	7	64	10.9	0	21	0.0	0	22	0.0
Carabelli's Cusp Maxillary Deciduous 1st Molar	1	5	20.0	1	5	20.0	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0
Carabelli's Cusp Mandibular Deciduos 1st Molar	3	5	60.0	3	5	60.0	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0
Carabelli's Cusp Maxillary Permanent 1st Molar	2	6	33.3	2	6	33.3	3	33	9.1	3	33	9.1	1	12	8.3	1	12	8.3
Carabelli's Cusp Mandibular Permanent 1st Molar	3	5	60.0	3	5	60.0	9	41	22.0	8	40	20.0	1	13	7.7	1	13	7.7
Sixth Cusp Mandibular Permanent 2nd Molar	0	5	0.0	0	4	0.0	0	41	0.0	1	45	2.2	0	17	0.0	0	14	0.0
Maxillary Third Molar	1	1	100.0	2	2	100.0	29	44	65.9	27	44	61.4	4	12	33.3	6	15	40.0
Mandibular Third Molar	2	2	100.0	1	1	100.0	36	54	66.7	40	59	67.8	10	21	47.6	8	17	47.1

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Peg Tooth*	0	11	0.0				1	69	1.4				0	24	0.0			
Shovel Shaped Incisors*	0	11	0.0				2	69	2.9				0	24	0.0			
Congenital Absence of Dentition*	0	11	0.0				0	69	0.0				0	24	0.0			
Supernumerary Dentition*	0	11	0.0				1	69	1.4				0	24	0.0			
Talan Cusp*	0	11	0.0				1	69	1.4				0	24	0.0			
Late Eruption of Canines*	0	11	0.0				1	69	1.4				1	24	4.2			
Enamel Pearls*	0	11	0.0				0	69	0.0				0	24	0.0			
Suprascapular Foramen	0	7	0.0	1	8	12.5	2	61	3.3	2	63	3.2	0	19	0.0	1	17	5.9
Acromial Articular Facet	0	7	0.0	0	8	0.0	0	61	0.0	0	63	0.0	1	19	5.3	0	17	0.0
Accessory Clavicle Facet	0	9	0.0	0	6	0.0	12	59	20.3	11	59	18.6	2	20	10.0	1	20	5.0
Sternal Aperture*	0	3	0.0				1	33	3.0				0	9	0.0			
Humeral Supracondylar Process	0	12	0.0	0	10	0.0	1	68	1.5	1	66	1.5	0	20	0.0	0	19	0.0
Humeral Septal Aperture	0	12	0.0	0	10	0.0	5	68	7.4	4	66	6.1	2	20	10.0	3	19	15.8
Humeral Osteoma	0	12	0.0	0	10	0.0	0	69	0.0	0	66	0.0	0	20	0.0	0	19	0.0
Proximal Phalanx Osteoma	0	8	0.0	0	7	0.0	0	62	0.0	0	60	0.0	1	20	5.0	0	18	0.0
Single Atlas Articulating Facet	5	7	71.4	4	5	80	43	52	82.7	43	51	84.3	16	18	88.9	17	19	89.5
Double Atlas Articulating Facet	2	7	28.6	1	5	20	9	52	17.3	8	51	15.7	2	18	11.1	2	19	10.5
Occipitocervical Cranial Border Shift*	0	9	0.0				0	54	0.0				0	19	0.0			
Bifurcation of C1 Neural Arch*	0	9	0.0				1	53	1.9				1	19	5.3			
Clefting of C1 Neural Arch*	0	8	0.0				0	53	0.0				0	19	0.0			
Bifurcation of C1 Anterior Neural Arch*	0	9	0.0				0	53	0.0				0	19	0.0			
Block Fusion of C2 and C3*	0	8	0.0				0	57	0.0				0	22	0.0			
Block Fusion of C3 and C4*	0	8	0.0				1	56	1.8				0	22	0.0			
Block Fusion of C4 and C5 *	0	7	0.0				1	57	1.8				0	18	0.0			
Block Fusion of C5 and C6*	0	8	0.0				0	57	0.0				0	17	0.0			
Block Fusion of C6 and C7 *	0	8	0.0				0	59	0.0				0	18	0.0			
Block Fusion of C7 and T1*	0	8	0.0				1	59	1.7				0	18	0.0			
Cervicothoracic Cranial Border Shift*	0	8	0.0				0	63	0.0				0	18	0.0			

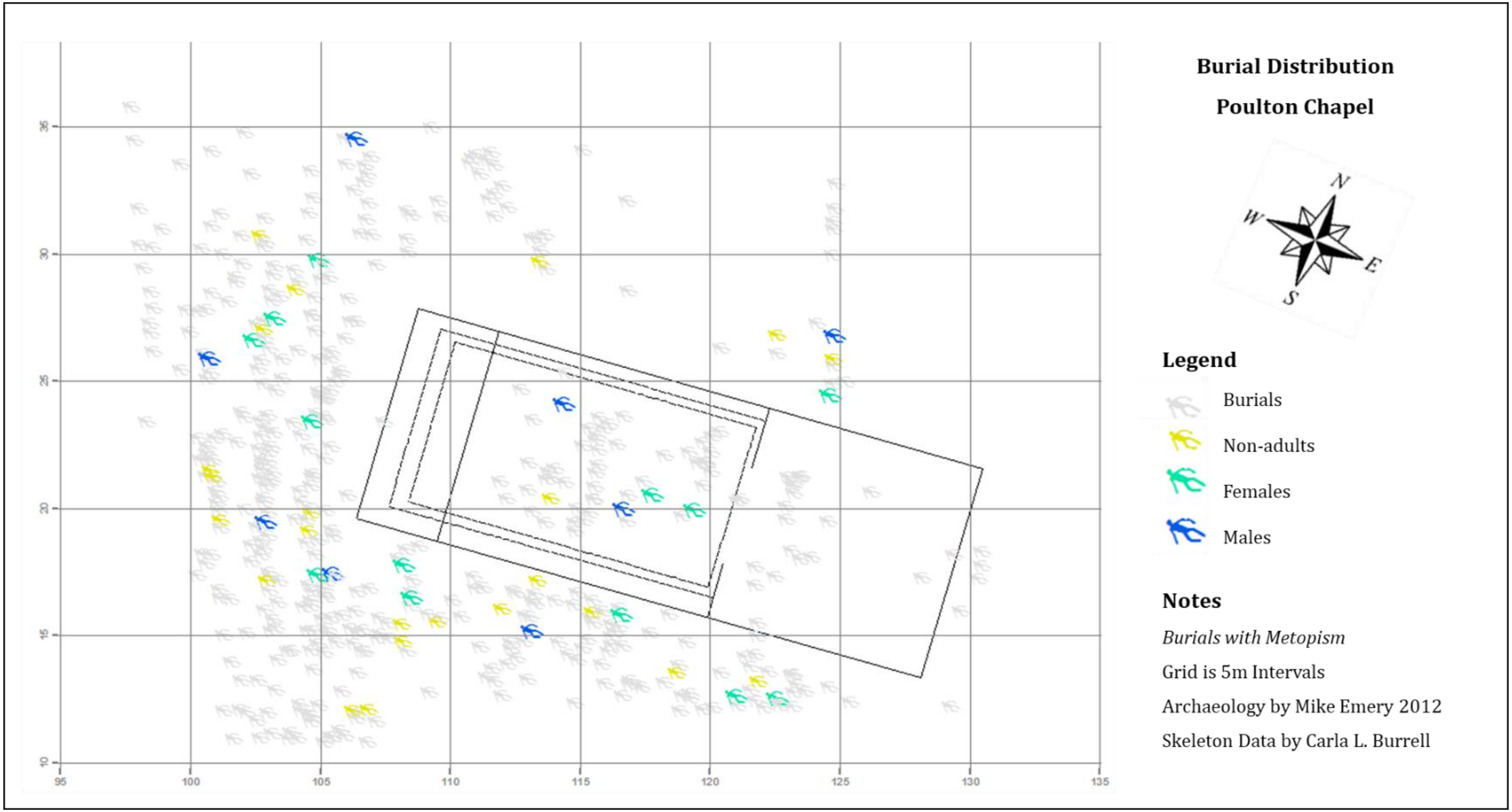
Continued...

Extra Thoracic Vertebrae*	0	8	0.0				0	63	0.0				0	20	0.0			
Thirteenth Rib	0	2	0.0	0	2	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0
Bifid Rib	0	9	0.0	0	9	0.0	0	62	0.0	0	63	0.0	0	19	0.0	0	19	0.0
Flared Rib	0	9	0.0	0	6	0.0	0	63	0.0	0	36	0.0	0	19	0.0	0	12	0.0
Congenital Absence of Thoracic Vertebrae*	0	7	0.0				0	63	0.0				0	19	0.0			
Block Fusion of T7 and T8*	0	7	0.0				2	62	3.2				0	19	0.0			
Block Fusion of T8 and T9*	0	7	0.0				2	62	3.2				0	19	0.0			
Block Fusion of T9 and T10*	0	7	0.0				2	62	3.2				0	19	0.0			
Block Fusion of T10 and T11*	0	7	0.0				1	62	1.6				0	19	0.0			
Thoracolumbar Border Caudal Shift*	0	8	0.0				0	61	0.0				2	19	10.5			
Lumbarisation of S1	1	8	12.5				3	60	5.0				0	18	0.0			
Block Fusion of L1 and L2*	0	8	0.0				0	60	0.0				0	18	0.0			
Spondylolysis of L4 Neural Arch*	0	8	0.0				1	61	1.6				0	18	0.0			
Spondylolysis of L5 Neural Arch*	0	9	0.0				3	61	4.9				0	18	0.0			
Bifurcation of L5 Neural Arch*	0	9	0.0				1	61	1.6				0	18	0.0			
Clefting of L5 Neural Arch*	1	9	11.1				0	61	0.0				0	18	0.0			
Extra Lumbar Vertebrae*	0	8	0.0				2	61	3.3				1	18	5.6			
Lumbarisation of L6	0	0	0.0				0	1	0.0				0	0	0.0			
Sacralisation of L6*	0	0	0.0				0	1	0.0				0	0	0.0			
Spondylolysis of L6 Arch*	0	0	0.0				0	2	0.0				0	0	0.0			
Bifurcation of L6 Neural Arch*	0	0	0.0				0	2	0.0				0	0	0.0			
Clefting of L6 Neural Arch*	0	0	0.0				0	2	0.0				0	0	0.0			
Accessory Lumbar Facet*	0	9	0.0				0	60	0.0				0	18	0.0			
Bifurcation of S1 Neural Arch*	0	7	0.0				2	52	3.8				3	15	20.0			
Clefting of S1 Neural Arch*	1	7	14.3				2	52	3.8				1	15	6.7			
Bifurcation of S2 Neural Arch*	0	6	0.0				0	38	0.0				1	11	9.1			
Clefting of S2 Neural Arch*	1	6	16.7				1	38	2.6				1	11	9.1			
Spina Bifida Occulta *	1	6	16.7				6	42	14.3				3	15	20.0			

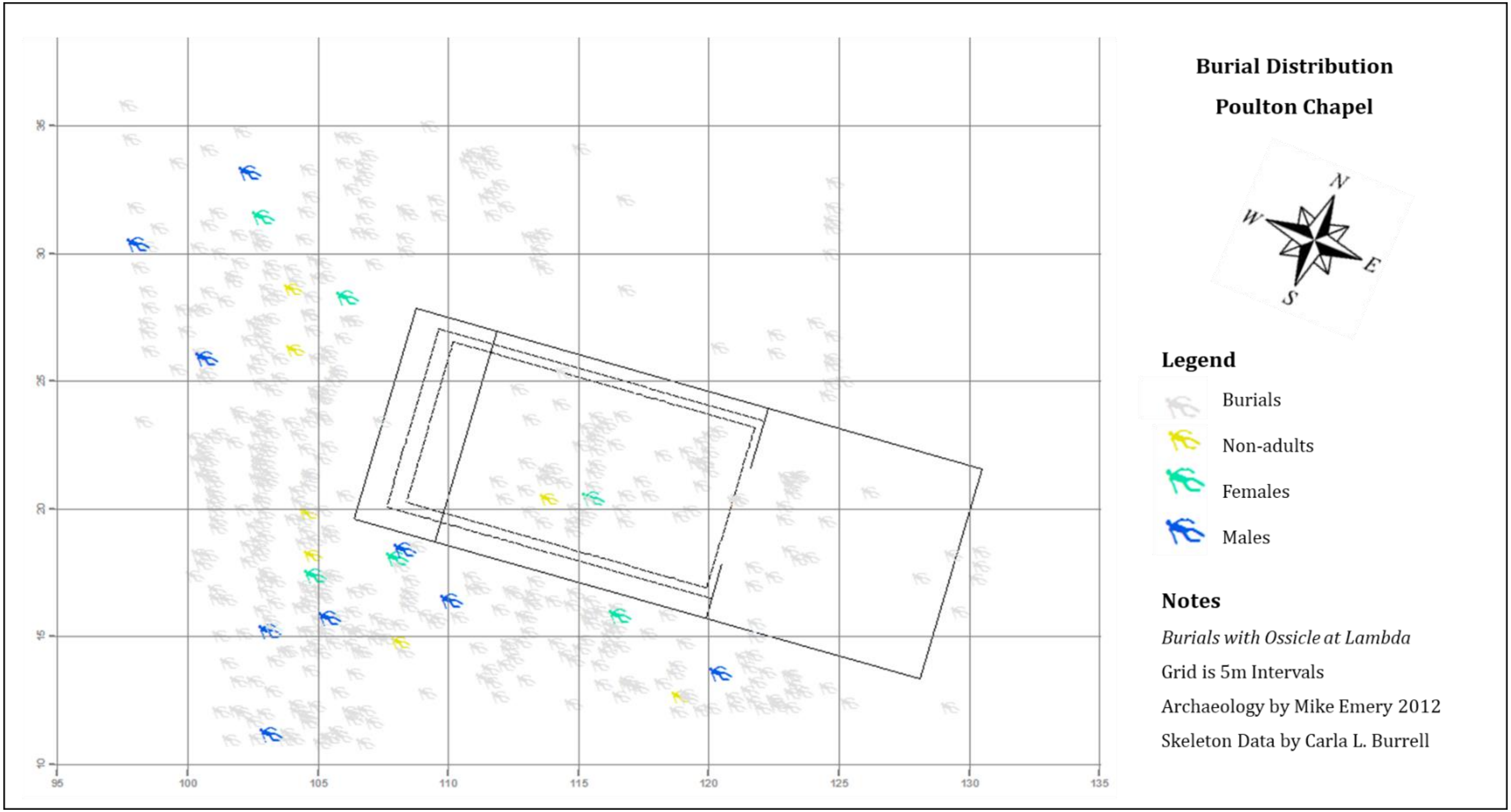
Continued…

Accessory Sacral Facet	1	9	11.1	2	10	20.0	10	63	15.9	8	64	12.5	1	20	5.0	2	18	11.1
Ilium Foramen	9	10	90.0	10	10	100.0	47	64	73.4	46	65	70.8	11	21	52.4	11	19	57.9
Sacroiliac Joint Fusion	0	10	0.0	0	10	0.0	2	63	3.2	2	63	3.2	1	19	5.3	0	17	0.0
Acetabular Crease	0	9	0.0	0	9	0.0	2	64	3.1	3	63	4.8	0	18	0.0	0	18	0.0
Femoral Osteoma	0	12	0.0	0	10	0.0	0	66	0.0	0	62	0.0	0	22	0.0	1	20	5.0
Femoral Supracondylar Process	0	12	0.0	0	10	0.0	0	66	0.0	0	62	0.0	0	23	0.0	0	21	0.0
Femoral Anteversion	0	12	0.0	2	10	20.0	1	66	1.5	0	62	0.0	0	23	0.0	0	21	0.0
Allen's Fossa	0	12	0.0	0	10	0.0	1	57	1.8	0	56	0.0	1	18	5.6	1	17	5.9
Poirier's Facet	0	12	0.0	0	10	0.0	2	57	3.5	5	56	8.9	1	18	5.6	1	17	5.9
Plaque Formation	0	12	0.0	0	10	0.0	4	57	7.0	5	56	8.9	0	18	0.0	0	17	0.0
Hypertrochanteric Fossa	3	12	25.0	2	10	20.0	38	64	59.4	35	62	56.5	8	20	40.0	6	19	31.6
Third Trochanter	1	12	8.3	1	10	10.0	9	64	14.1	8	61	13.1	4	20	20.0	4	19	21.1
Vastus Notch	0	3	0.0	0	3	0.0	6	38	15.8	7	41	17.1	0	9	0.0	0	8	0.0
Tibia Anteversion	0	11	0.0	1	9	11.1	1	63	1.6	1	62	1.6	0	19	0.0	0	19	0.0
Tibia Osteoma	0	11	0.0	0	9	0.0	2	63	3.2	2	62	3.2	0	19	0.0	0	19	0.0
Squatting Facet	2	3	66.7	1	3	33.3	14	47	29.8	15	46	32.6	7	15	46.7	8	17	47.1
Inferior Talus Single Articular Facet	2	4	50	2	4	50	21	45	46.7	24	44	54.5	17	17	100.0	15	15	100.0
Inferior Talus Double Articular Facet	2	4	50	2	4	50	24	45	53.3	19	44	45.5	0	17	0	0	15	0
Single Calcaneal Articular Facet	3	5	60	2	3	66.7	20	45	44.4	26	47	55.3	17	18	94.4	16	16	100.0
Double Calcaneal Articular Facet	2	5	40	1	3	33.3	25	45	55.6	21	47	44.7	1	18	5.6	0	16	0
Peroneal Tubercle	0	4	0.0	0	3	0.0	7	44	15.9	8	44	18.2	1	15	6.7	1	14	7.1
Metatarsal Osteoma	0	4	0.0	0	3	0.0	0	45	0.0	0	45	0.0	0	15	0.0	0	14	0.0

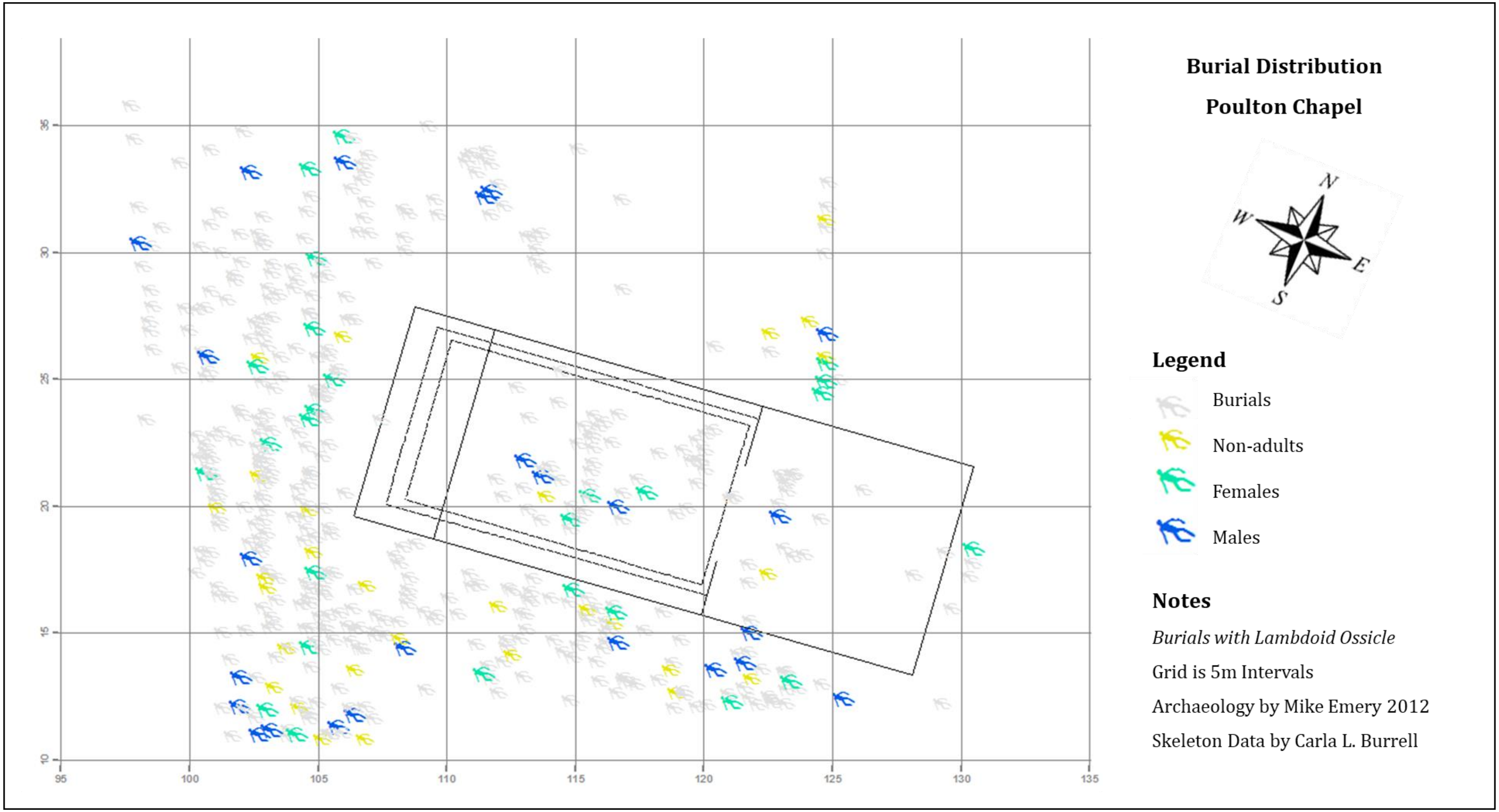
9 Burial Distribution Map of Poulton Chapel: Metopism



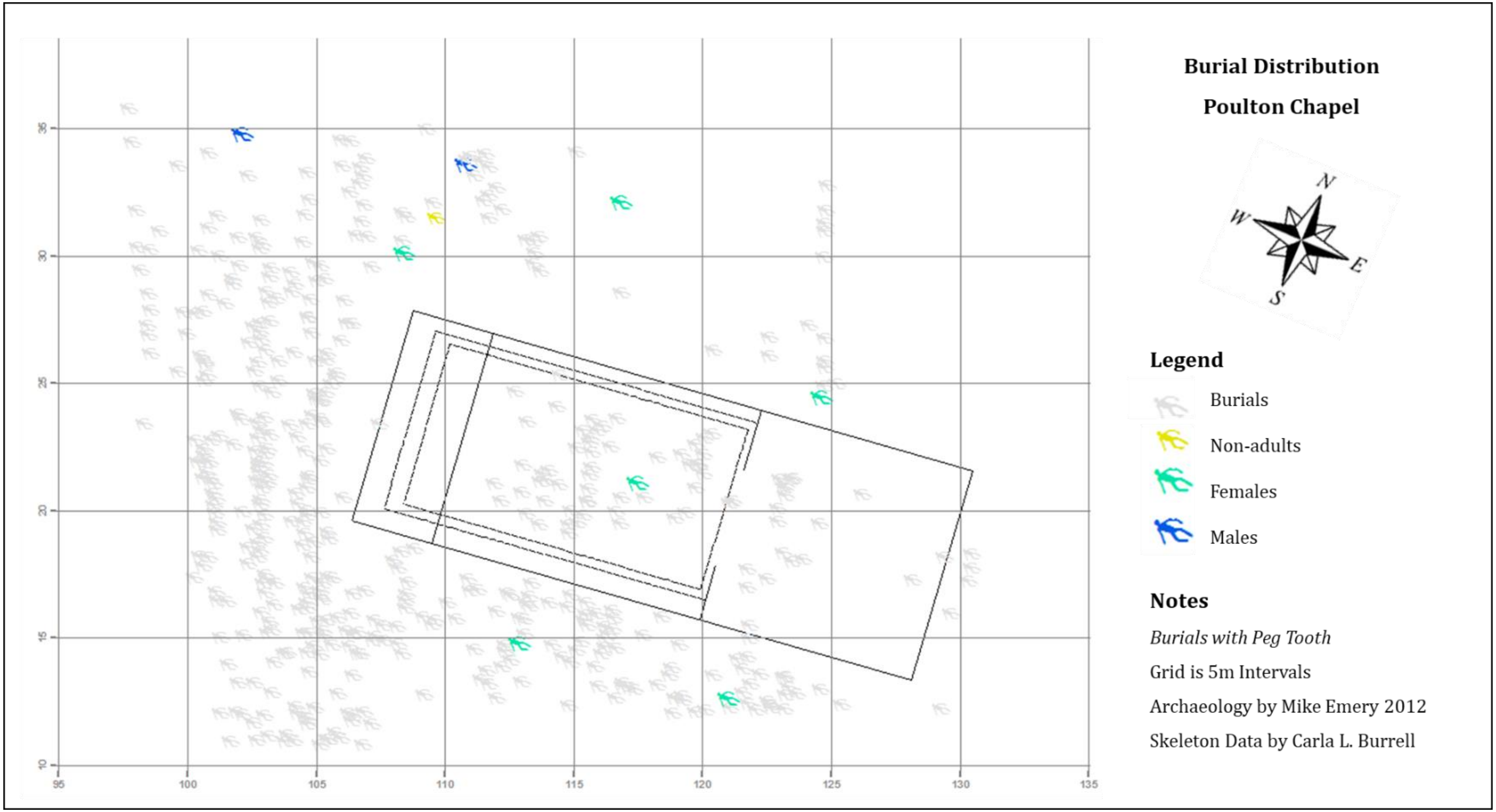
10 Burial Distribution Map of Poulton Chapel: Ossicle at Lambda



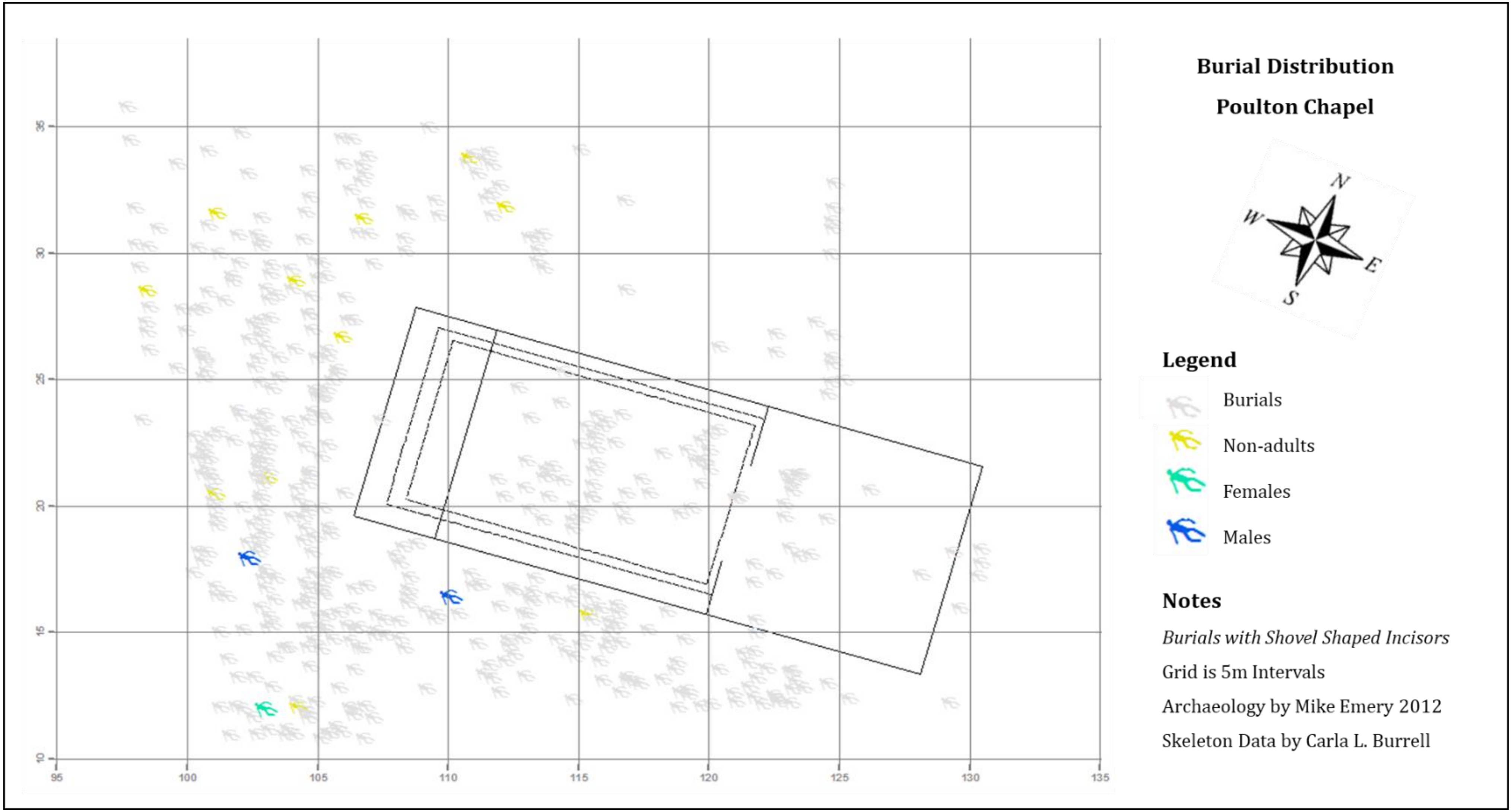
11 Burial Distribution Map of Poulton Chapel: Lambdoid Ossicle



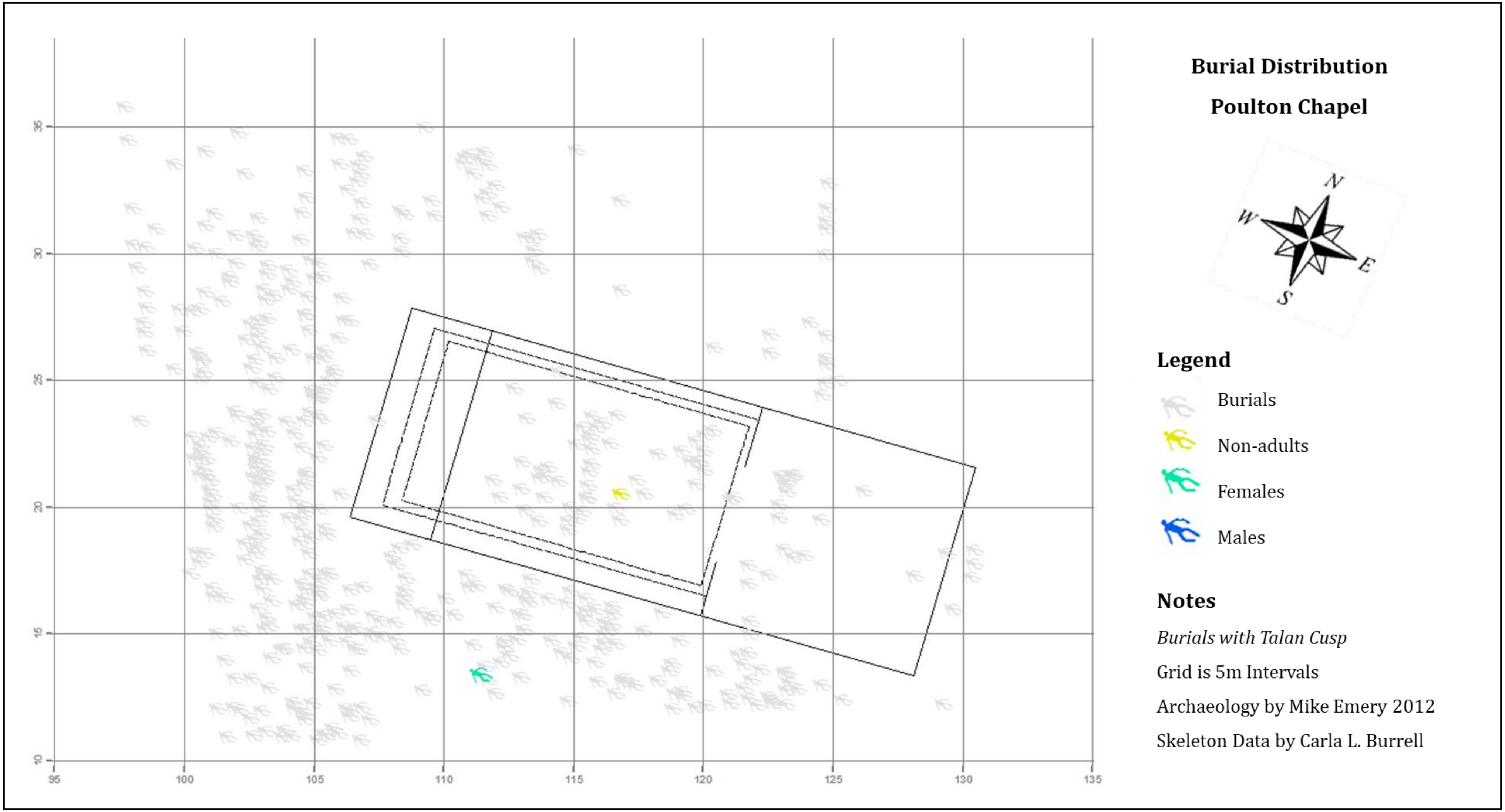
12 Burial Distribution Map of Poulton Chapel: Peg Tooth



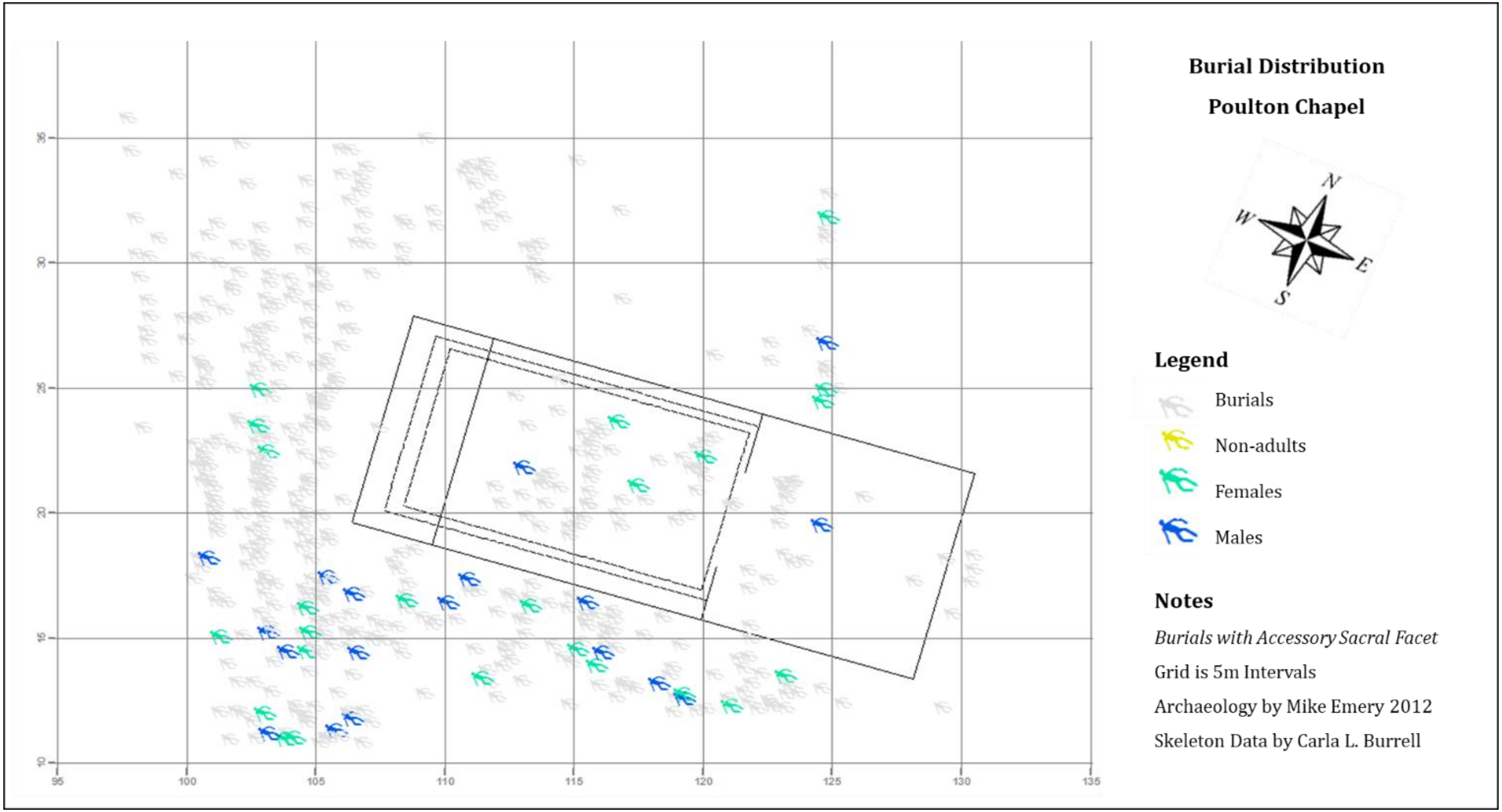
13 Burial Distribution Map of Poulton Chapel: Shovel Shaped Incisors



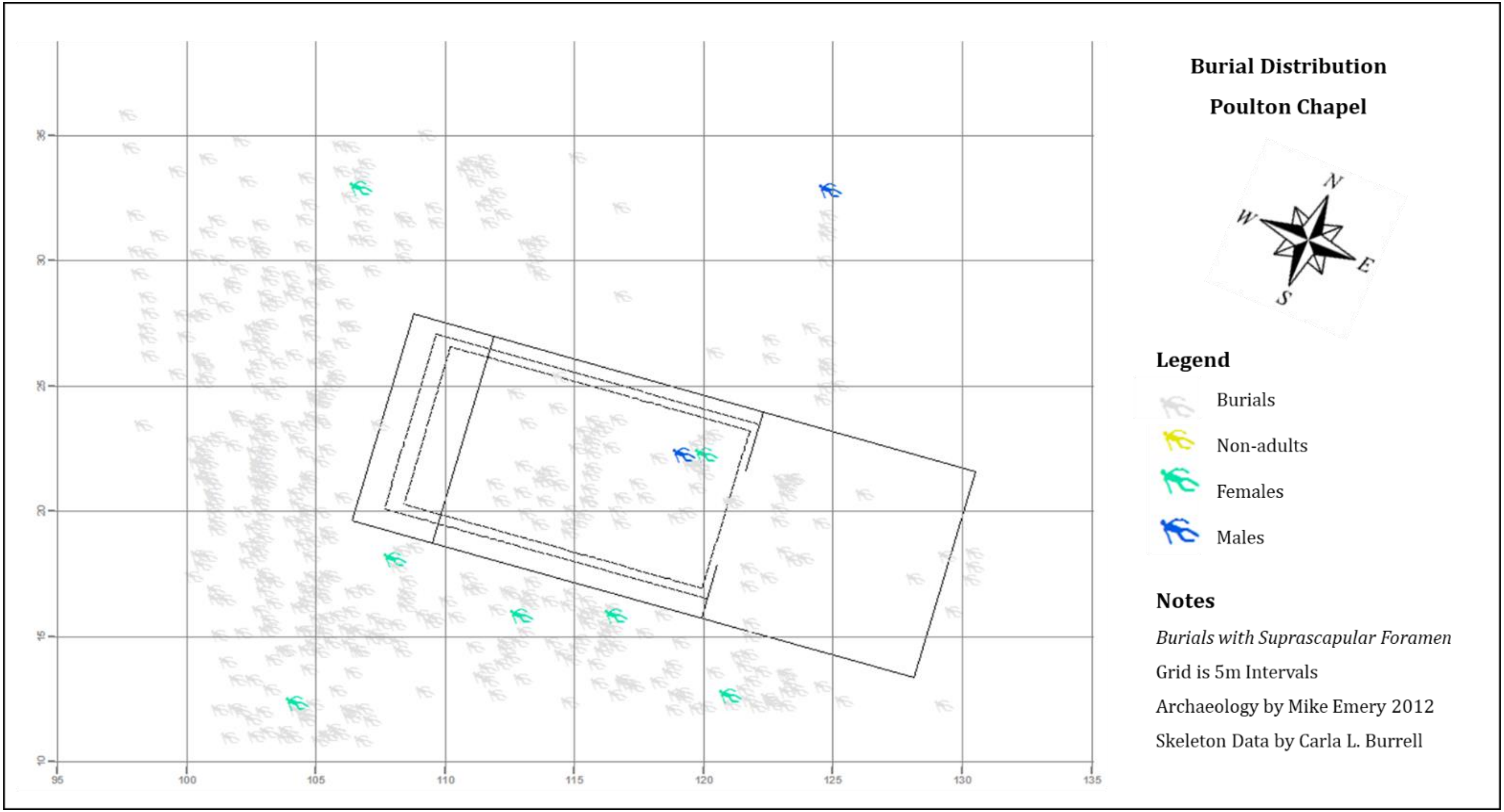
14 Burial Distribution Map of Poulton Chapel: Talan Cusp



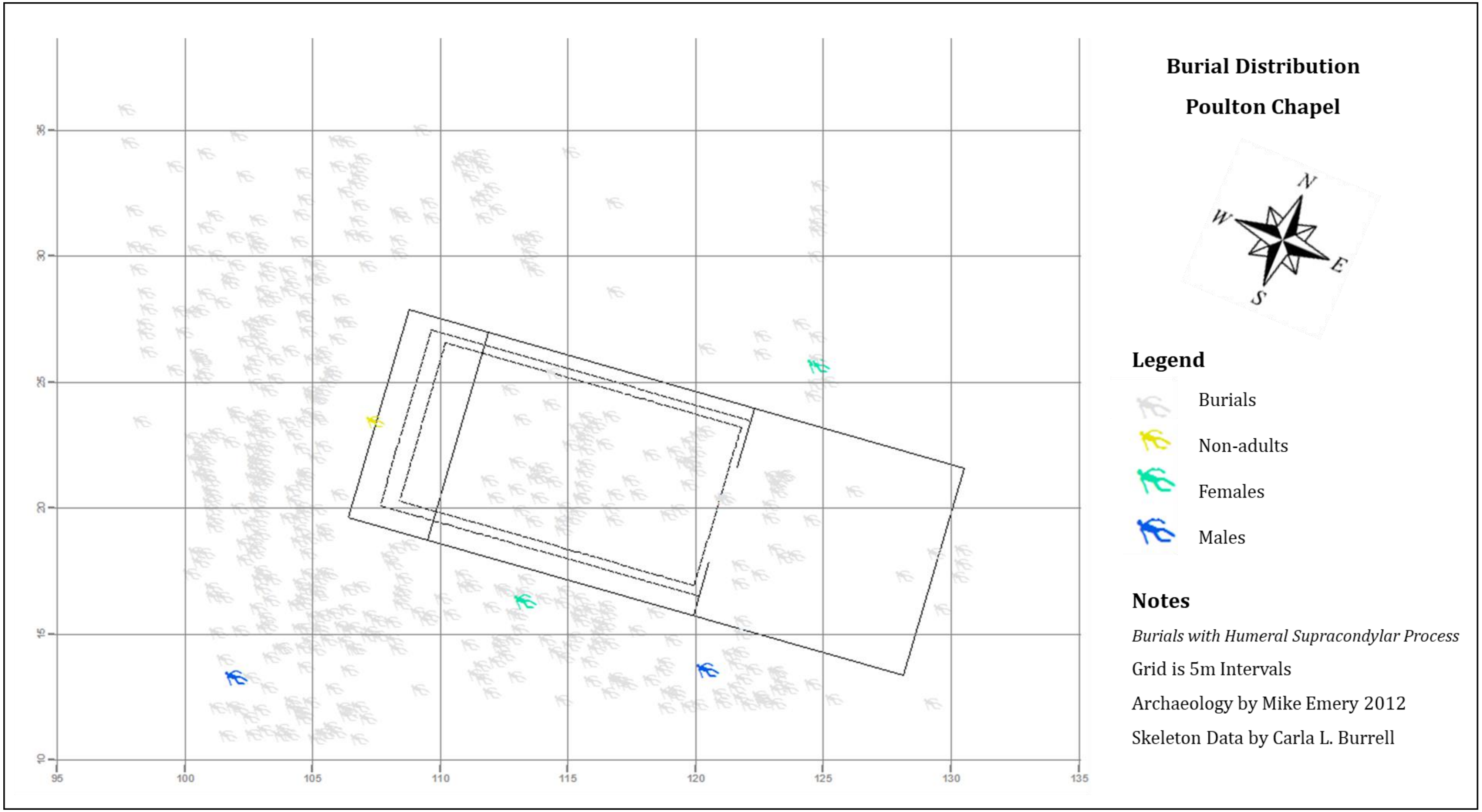
15 Burial Distribution Map of Poulton Chapel: Accessory Sacral Facet



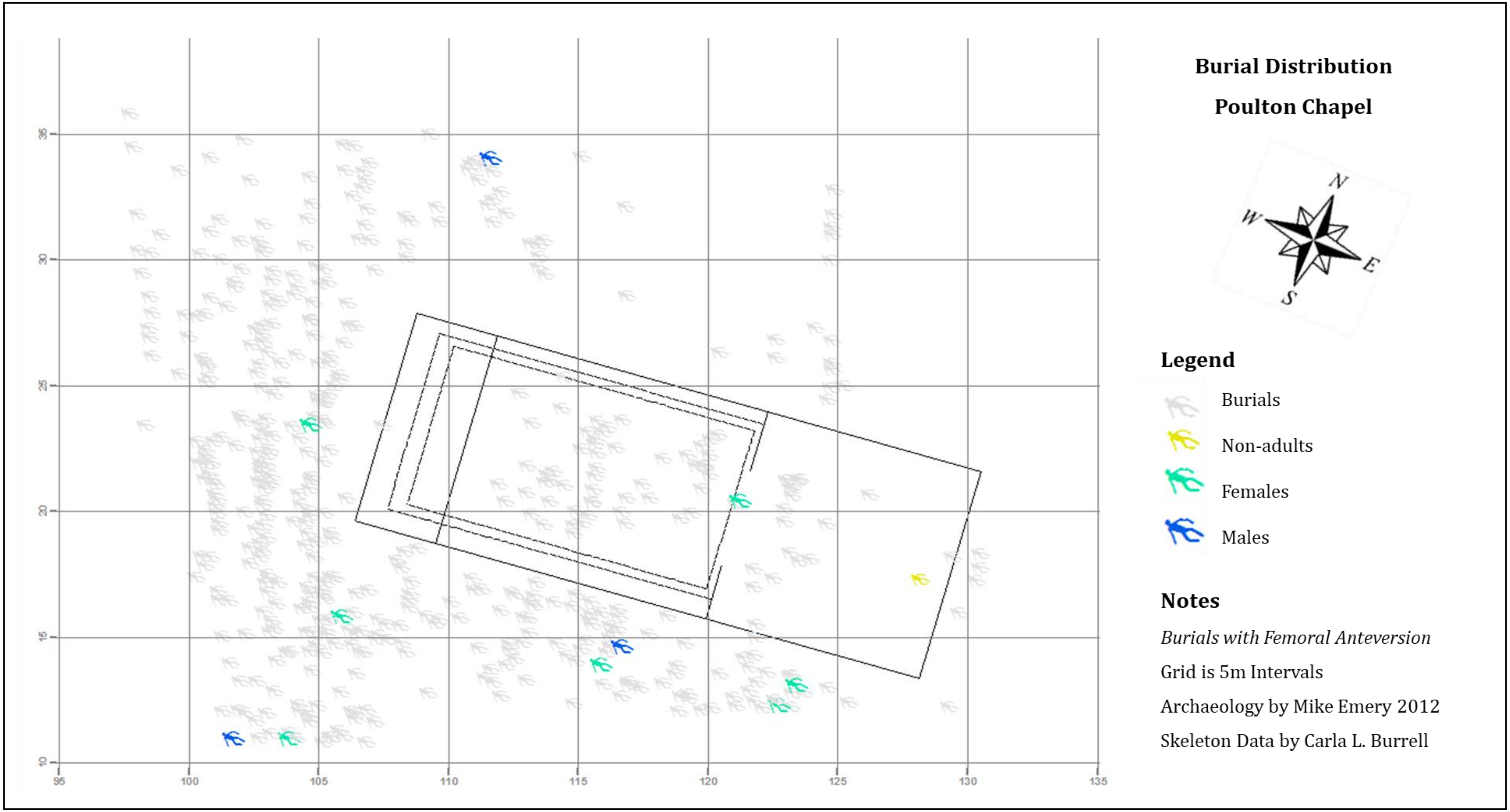
16 Burial Distribution Map of Poulton Chapel: Suprascapular Foramen



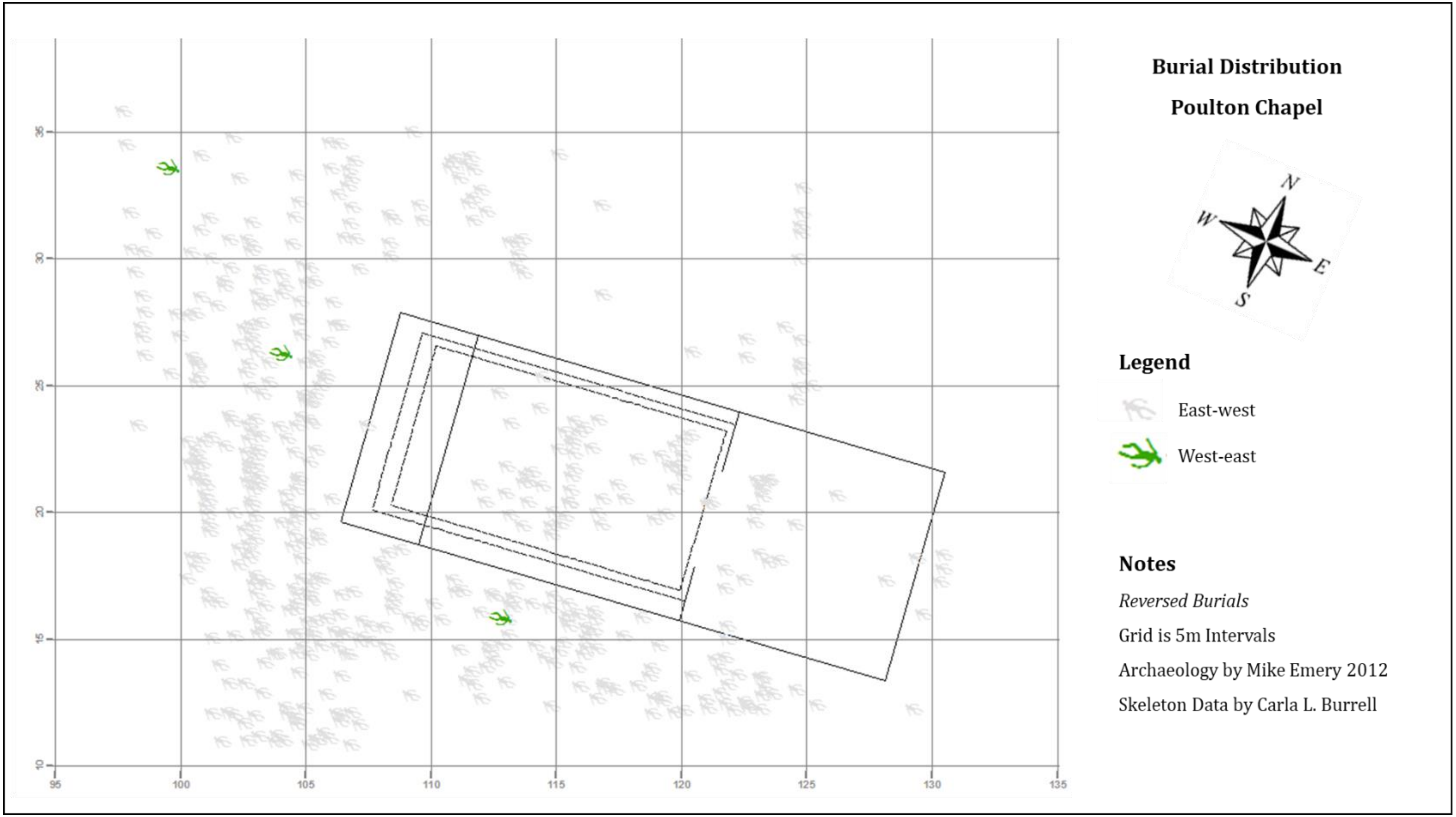
17 Burial Distribution Map of Poulton Chapel: Humeral Supracondylar Process



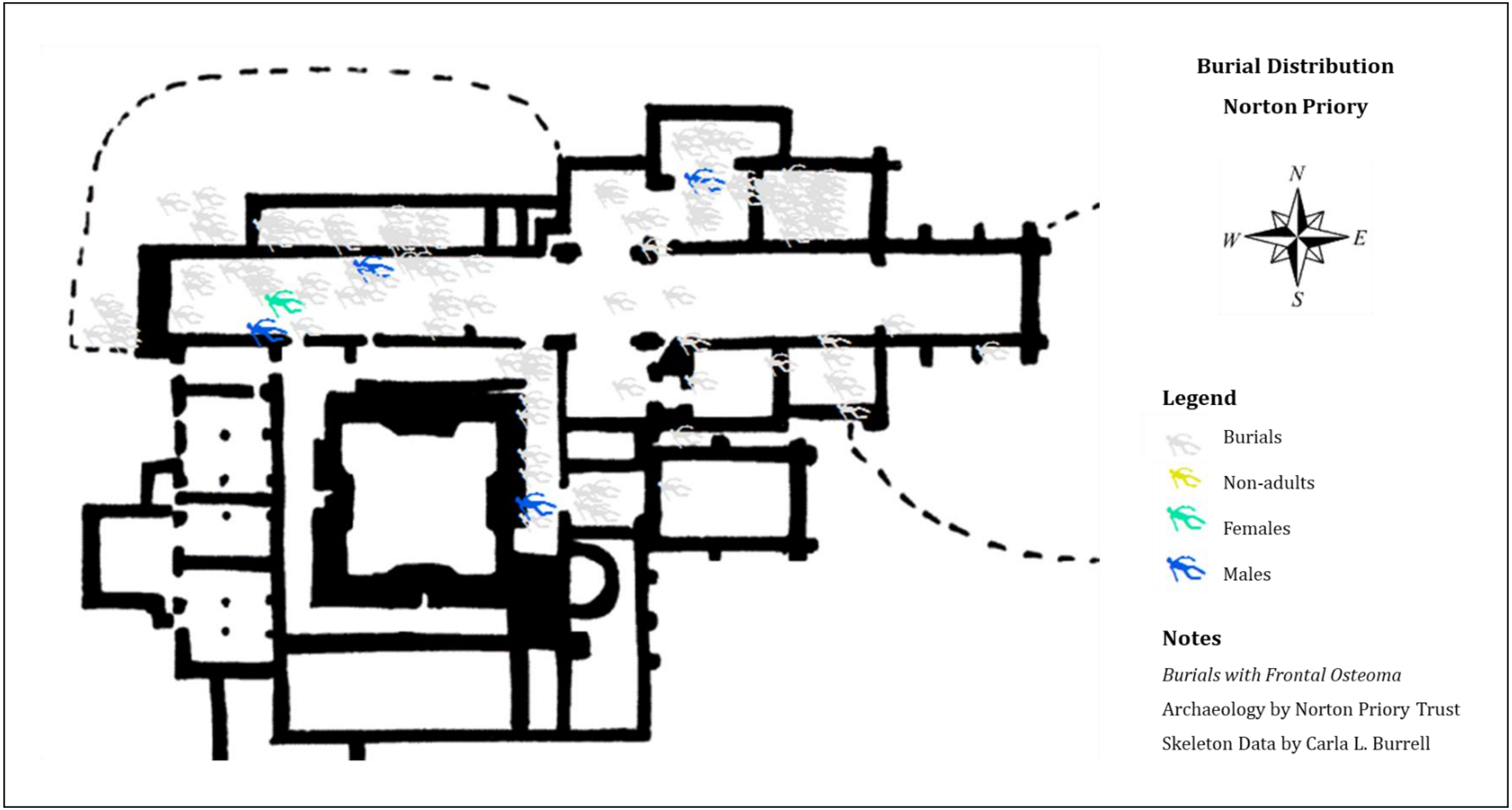
18 Burial Distribution Map of Poulton Chapel: Femoral Anteversion



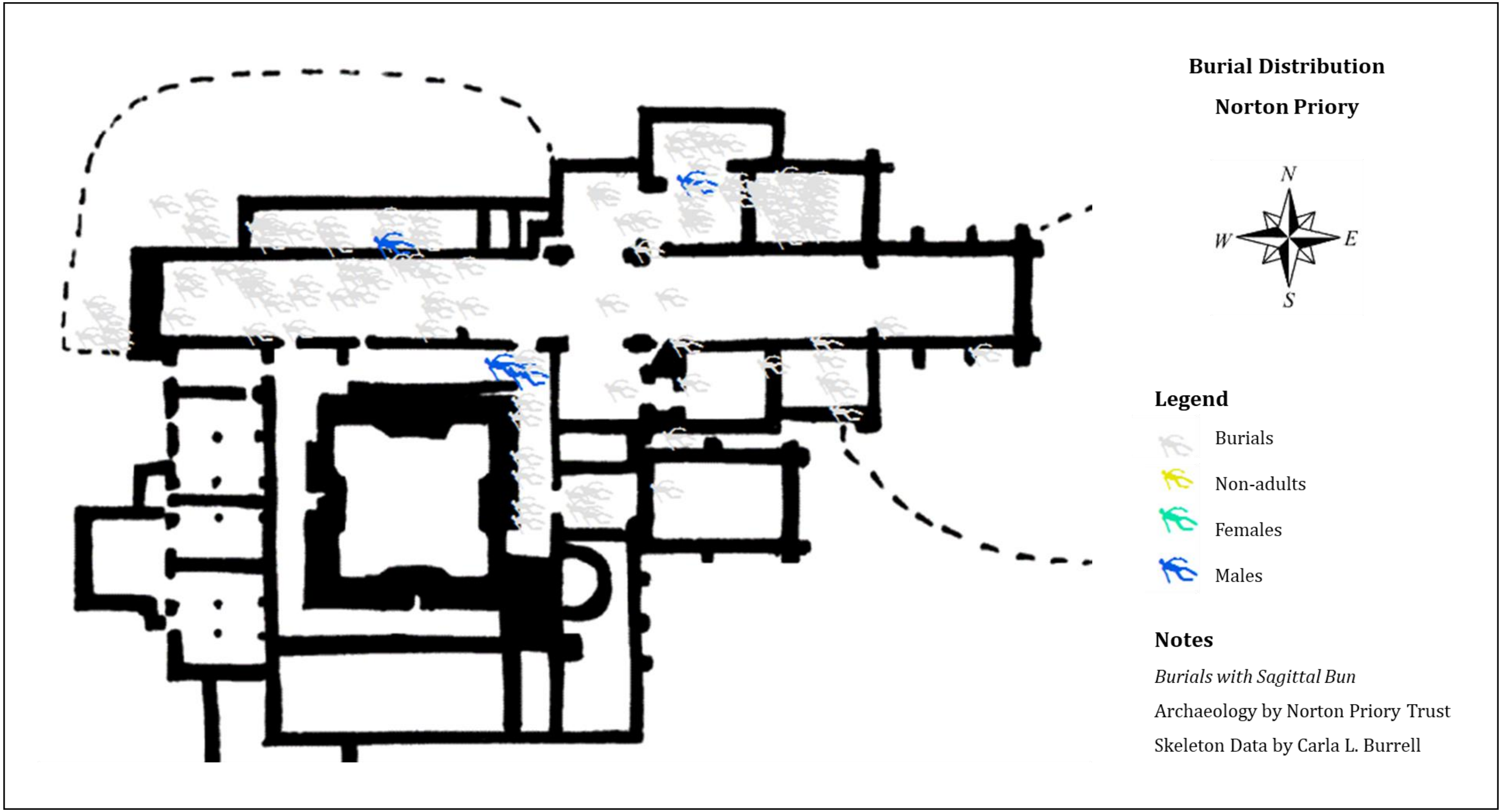
19 Burial Distribution Map of Poulton Chapel: Reversed Burials



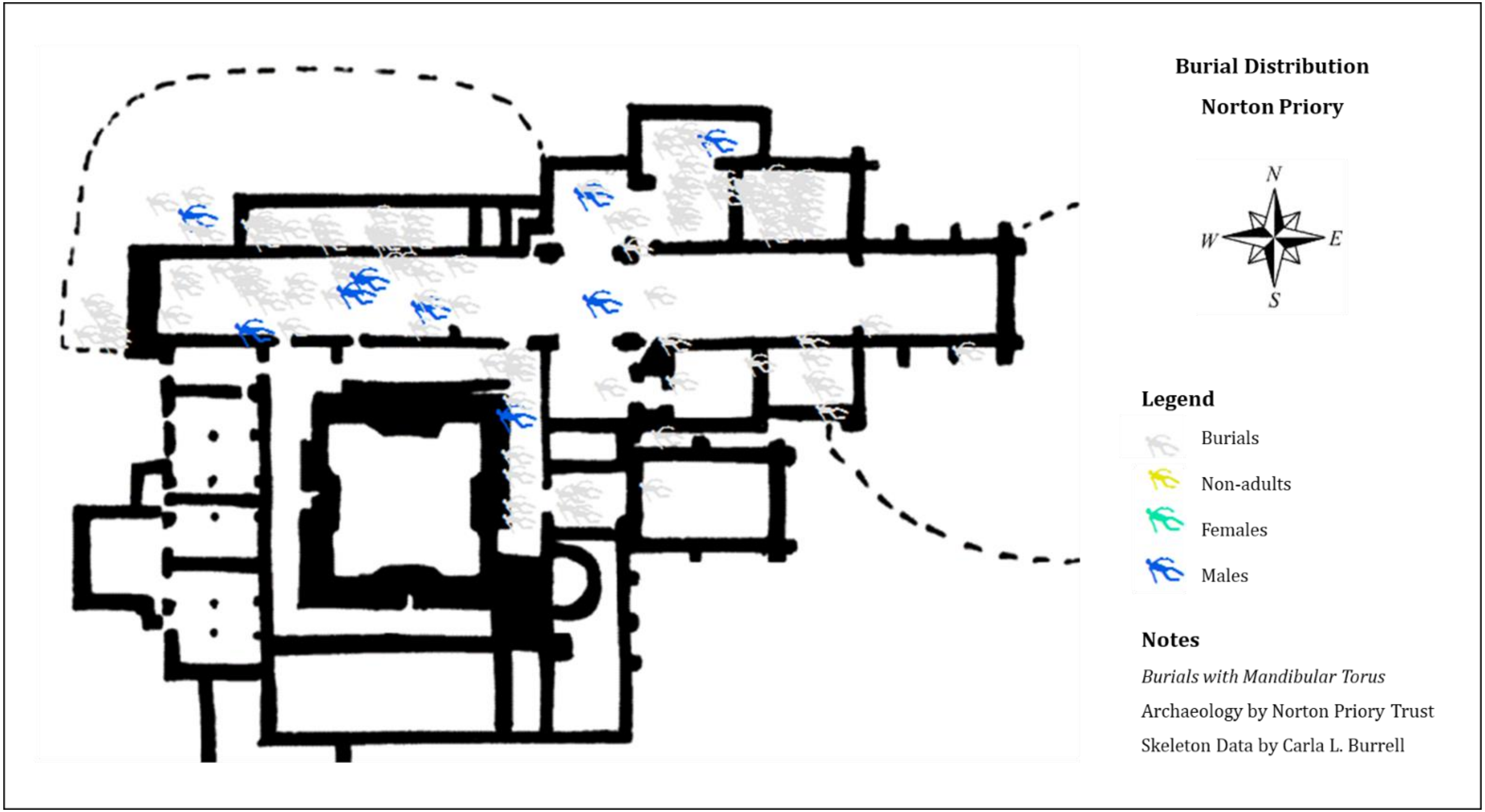
20 Burial Distribution Map of Norton Priory: Frontal Osteoma



21 Burial Distribution Map of Norton Priory: Sagittal Bun



22 Burial Distribution Map of Norton Priory: Mandibular Torus



23 Burial Distribution Map of Norton Priory: Tibia Osteoma