SUBADULT GROWTH AND RICKETS FROM A LATE ROMAN AND MEROVINGIAN PERIOD CONTEXT IN LISIEUX, FRANCE

SUBADULT GROWTH AND RICKETS FROM A LATE ROMAN AND MEROVINGIAN PERIOD CONTEXT IN LISIEUX, FRANCE

By Sarah Timmins

A Thesis

Submitted to the School of Graduate Studies

in Partial Fulfillment of the Requirements

for the Degree

Master of Arts

McMaster University

© Copyright by Sarah Timmins, June 2016

MASTER OF ARTS (2016)
Department of Anthropology
McMaster University
Hamilton, Ontario
TITLE: Subadult Growth and Rickets From a Late Roman and Merovingian Period Context in Lisieux, France

AUTHOR: Sarah Timmins

SUPERVISOR: Dr. Megan Brickley

NUMBER OF PAGES: xv, 238

ABSTRACT

The transition during the fall of the Roman Empire and eventual rise of Merovingian kingdoms in northern Gaul (modern France) was a period of political upheaval, and social and economic instability. A collection of subadult skeletal remains dating to the late Roman (3rd – 5th c. AD) and Merovingian period (5th – 8th c. AD) in modern day Lisieux, France, permitted an analysis of the effects of these purported stresses on past population health using measures of growth and development. The four aims of this study are to: 1) identify growth delay using measures of growth and development; 2) determine the prevalence of rickets in this sample; 3) determine if growth disruption and frequency of rickets varied between subadults of different ages, time periods, from different burial types, or those associated with and without grave goods; and 4) discuss how the results of this study contribute to an understanding of the interpretation of health at the site, and the social, cultural, and environmental circumstances that impacted health in the past. The remains of 130 subadults from the Michelet necropolis were examined for the presence of rickets as a part of the SSHRC funded project 'Social-Cultural Determinants of Community Wellbeing in the Western Roman Empire: Analysis and Interpretation of Vitamin D Status.' A subset of this sample (N=60) was used further to examine disruptions in endochondral growth, appositional growth, cortical thickness, and body mass estimates. Results indicate over half (53%) of the sample exhibited stunting with growth delay beginning around two years of age, highly variable cortical thickness for age, as well as low estimates of body mass for age. Approximately 9% of subadults (N=12/130) analysed exhibited pathological and radiographic features characteristic of rickets. There were no differences between patterns of growth faltering and presence of rickets during the two time periods, between individuals with or without grave goods, or between those in different burial types. The presence of growth faltering and rickets demonstrates that this population experienced nutritional stresses, but that there were no measurable changes in health between the Roman and Merovingian periods.

ACKNOWLEDGEMENTS

I would like to express my gratitude to a number of individuals who have given valuable guidance and support through the completion of this project. First and foremost I would like to thank my MA thesis supervisor Dr. Brickley for guiding me through the process of developing a research project, sending me to Europe for my data collection, and in the final stages of the completion of my thesis. I too extend thanks to Dr. Prowse, my committee member, and Dr. Moffat the third reader for their time and consideration of my work. I would also like to send a very special thank you overseas to Dr. Cécile Chapelain de Seréville-Niel and her colleagues at the Université de Caen for the kind welcome and support during my data collection in Caen, France. I would like to recognize the generous funding I received from the Social Sciences and Humanities Research Council, the Social Sciences and Humanities Research Council of Canada Insight Grant (File number 435-2013-1006, ID #169793) through my supervisor and Dr. Prowse as part of their grant, and the Edith M. Whitman Travel Scholarship. Lastly, I would like to thank my loving family and friends for their unending support and kindness.

TABLE OF CONTENTS

LIST OF TABLES

Chapter 4

Chapter 5

LIST OF FIGURES

Chapter 2

Chapter 3

Chapter 4

Chapter 5

LIST OF EQUATIONS

Chapter 4

Declaration of Academic Achievement

This is a declaration that the current study was completed by Sarah Timmins under the supervision of Dr. Brickley, and with guidance from Dr. Prowse my committee member. Macroscopic recording for the SSHRC funded project 'Social-Cultural Determinants of Community Wellbeing in the Western Roman Empire: Analysis and Interpretation of Vitamin D Status' was undertaken by Sarah Timmins with contributions from Lisa Semchuck. Radiographic analysis was conducted by Sarah Timmins with the permission and use of radiographic equipment from Dr. Ribot from the University of Montréal. Macroscopic and radiographic analysis was undertaken at the Université de Caen, France.

Chapter 1: Introduction

The vast expanse of territory held by the Roman Empire at its peak in the 2nd and 3rd centuries AD resulted in the incorporation of many diverse peoples, cultures and environments into the Empire. The subsequent fall of the Roman Empire during the 5th century AD saw the end of Roman control over Gaul (modern day France), the beginning of 'barbarian' rule, and the eventual establishment of the Merovingian kingdoms in the late 5th century AD. Historians write that this period of transition was characterized by social, political, and economic upheaval (Drinkwater and Elton 2002). A large archaeological collection of subadult skeletal remains of children who lived during this transitional period of history in France offered a unique opportunity to investigate the late Roman and Merovingian time period from a bioarchaeological perspective.

Bioarchaeological analyses frequently study subadult growth and development in order to understand past population health. The World Health Organization (WHO) defines health as, "a state of complete physical, mental, and social well-being and not merely the absence of disease, or infirmity" (World Health Organization 2014:1). The analysis of archaeological skeletal materials, even with contextual and historical data, do not allow for such complete investigation of past health as defined by the WHO. In bioarchaeological studies health has been approached as; "something that is compromised when any number of factors, including disease, infection, nutritional quality, or psychological factors, affect an individual's quality of life" (Reitsema and McIlvaine 2014:181). Disruptions of past health are quantified in skeletal materials using non-specific stress indicators and pathological skeletal lesions indicative of disease.

Specifically, this study utilized skeletal evidence for disruptions in normal growth and development as a proxy for gauging past population health. It is well established that subadults are one of the most vulnerable cohorts in a population, due to immature immune systems and rapid growth rate (Goodman and Armelagos 1989). These features of immaturity mean that subadults are sensitive indicators of environmental conditions in the past.

Recent bioarchaeological studies have investigated a number of measures of growth and development in response to various environmental stresses (e.g., McEwan et al. 2005; Pinhasi et al. 2006; Mays et al. 2008; Mays et al. 2009a; Mays et al. 2009b). Endochondral growth faltering, measured through comparisons of long bone length for age, has long been accepted and used as a measure of general health and stress within a population, with stunting resulting from a combination of factors including malnutrition and disease (Mays et al. 2009b; Vercellotti et al. 2014). Cortical thickness has also been investigated in clinical and bioarchaeological studies; however, most bioarchaeological studies have focused on adult remains (Hummert 1983). Research concerned with cortical thickness in subadult remains reports that endosteal resorption of cortical bone along with the continuation of appositional bone growth is a sensitive indicator of nutritional stress (Hummert 1983; Mays et al. 2009b).

Measurements of body mass are regularly used in anthropological studies evaluating childhood health (Kuklina et al. 2006; Ruff 2007). Variations in body size (i.e., stature and mass) are often used to assess health within and between populations, as improved nutrition and living conditions have been shown to result in greater weight and stature in subadults (Bogin 2001; Ruff 2007). Though body mass has long been used in anthropology, the first method for estimating living body mass from subadult skeletal remains was developed recently in 2007 by Ruff. After subadults begin walking and bearing weight on their legs, femoral measurements of the distal metaphysis and femoral head become correlated with body mass, allowing for the estimation of body mass from skeletal remains (Ruff 2007).

Clinical and archaeological findings suggest that rickets may significantly stunt individual overall height (Thacher et al. 2002; Mays et al. 2009a). Mays et al. (2009a) suggest that delayed growth in rachitic subadults results from a combination of delayed endochondral growth as well as bowing deformities. Conversely, Pinhasi et al. (2006) found no significant differences in long bone growth between subadults with and without skeletal manifestations of rickets.

Rickets and bone growth are two biological phenomena that are influenced by cultural processes. The biocultural approach considers stress and disease in past populations as “products of environmental inadequacies, whether socially, economically, politically or ecologically generated” (Zuckerman et al. 2012:35). Through the use of a biocultural lens, identifying patterns of growth faltering and nutritional stress, allows for a better understanding of the social, cultural and environmental circumstances surrounding childhood in late Roman and Merovingian Gaul.

The four primary aims of this study are to; 1) identify growth stunting using measures of endochondral growth, appositional growth, attainment of cortical thickness, and estimation of body mass, in a late Roman and Merovingian sample of subadult skeletal remains; 2) determine the frequency of rickets present in this sample; 3) determine if growth disruption and frequency of rickets varied between subadults of different ages, time periods, from different burial types, or those associated with and without grave goods; and 4) discuss how the results of this study contribute to an understanding of the interpretation of health at the site, and the social, cultural, and environmental circumstances that may have impacted subadult health in the past.

Chapter 2: Background – Historical Context

2.1 Late Roman and Merovingian Gaul

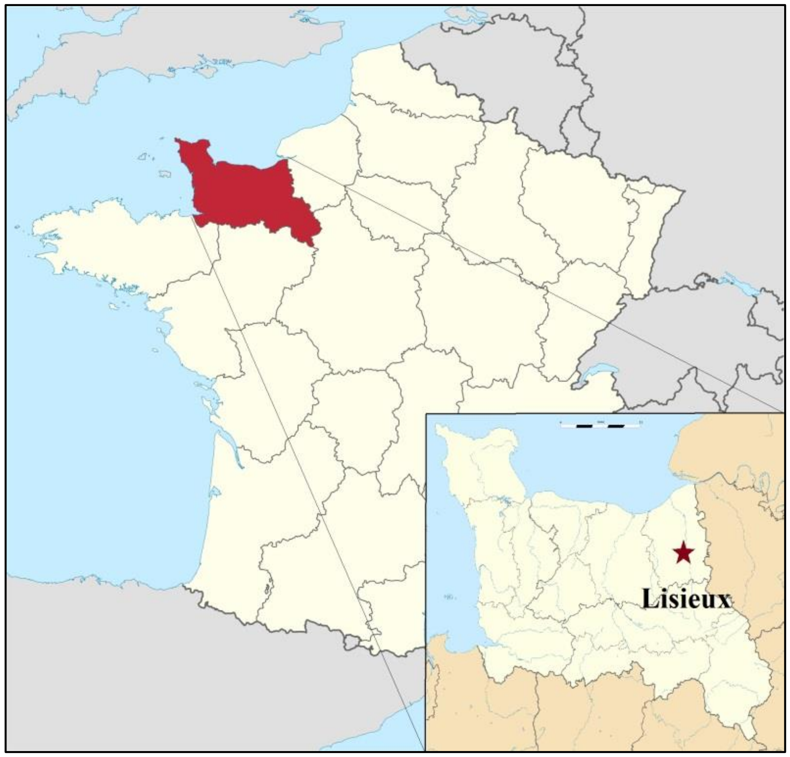
The sample analysed in this study dates to the late Roman Empire (late 3rd century to late 5th century AD) and Merovingian period (late 5th to late 8th century AD) in modern day northern France. This period is characterised by the fall of the Western Roman Empire, the beginning of Merovingian control and Frankish settlement, and rise of Christianity in Gaul (Mathisen 2006). Roman rule in Gaul began officially after Julius Caesar conquered the Gallic tribes in 58 BC; the subsequent Romanization of Gaul included the implementation of Latin language, currency, administration, Roman style architecture, and roadways (Drinkwater and Elton 2002; Mathisen 2006). Invasions and migrations of barbarian tribes into Gaul began around the 4th century AD and continued up to the 5th century AD (Mathisen 2006). The stability of the Western Roman Empire declined through the 5th century AD, and Roman control officially ended in 476 AD when the Roman Army elected Odoacer into power in Rome (Bleiber 1996).

The Franks, a barbarian group and once an ally of the Romans, originally located along the Rhine in the Netherlands, gained increasing power and presence in northern Gaul during the 5th century AD (Noble 2006). At the Battle of Soissons in 486 AD, the Franks eliminated the last Roman general holding power in Gaul (Collins 2010). Mathisen (2006) notes that many Gallo-Roman elites sought positions within the church instead of roles within the government in order to retain power after the fall of Rome and during the beginning of Merovingian rule. Historians claim that Gallo-Romans of lower social classes in northern Gaul maintained many of their ‘Roman’ customs under Merovingian rule (McCormick 2006). Christianity gained popularity during the 3rd and 4th centuries AD during the Roman period and became increasingly important during Merovingian rule (Fontaine 1996). The Merovingian kingdoms remained in power until the end of the 8th century AD when the Carolingian Empire began (Collins 2010).

2.2 *Noviomagus Lexoviorum*

Skeletal remains for this study were recovered from the Michelet necropolis associated with the Roman city of *Noviomagus Lexoviorum* located in modern day Lisieux, France (Fig. 2.1). The Roman city was settled during the 1st century AD in previous Gaulish territory belonging to the *Lexovii* tribe. In the 2nd century AD the settlement expanded to its peak (approximately 60 ha) and became a major urban and commercial centre in the area. The city intersected with many Roman roads and was located close to the sea where a port was likely to have been located (Paillard 2006).

Figure 2.1 – Lisieux, Normandy, France.



*** Image obtained from Wikimedia Commons. Adjustments made October 2015. (https://commons.wikimedia.org/wiki/File:France_location_map.svg)*

Archaeological work identified large-scale destruction and burning during the 3rd century AD attributed to Anglo-Saxon raiding. As a result, a *castrum* (fortress) was built at the end of the 3rd century and most of the settlement moved within these defenses. The *castrum* measured 400m x 200m and was able to defend approximately 8ha of land with an estimated population density of 400 people per hectare during the 4th century AD (Séguy and Buchet 2013). At this time, there was a noticeable change in burial customs from cremation to inhumation and additional cemeteries in the countryside were created, including the Michelet necropolis (Paillard 2006).

During the 4th and early 5th centuries AD there may have been a Roman legion stationed near the settlement. Several artifacts often found in military contexts dating from this period including bone combs, triangular brooches, and pins were recovered from the city. Additionally, there is a slightly higher proportion of females in early 5th century burials, which may indicate that men were absent due to military involvement (Paillard 2006). Paillard, one of the main archaeologists that excavated in the necropolis (2006) also surmised that it is likely the city suffered barbarian raids and destruction during the late 4th and 5th centuries related to the decline of the Roman Empire.

Less is known of the city during the Merovingian period (late 5th to late 8th c. AD). The city decreased in size within the *castrum* and the name of the city changed at this time to *Lexovii* (Paillard 2006). A church dedicated to Saint-Aignan was built during the 5th century AD, and in the 6th century AD the city was the seat of a bishopric held first by Theudobaudis (538-549 AD) (Paillard 2006). Grave goods with Christian symbols begin to appear in higher frequencies in the necropolis after the late 6th century AD (Paillard 2006).

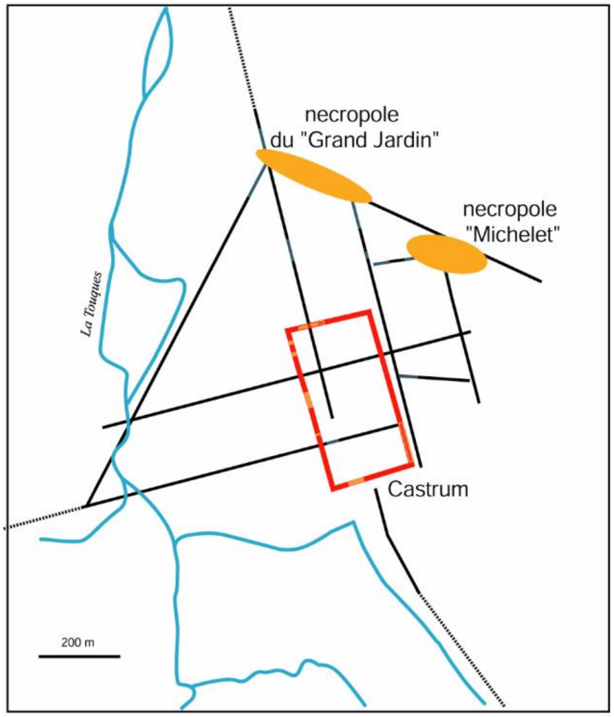
2.3 Michelet Necropolis

According to Paillard (2006), a small portion of the Michelet necropolis was discovered in the late 19th century, but systematic excavations did not take place until 1990 when a salvage operation was undertaken prior to the construction of a new road.

The first phase of excavation was conducted by Mr. Batrel, a municipal archaeologist of Lisieux. Following his findings, a four year salvage operation funded by the City of Lisieux, the Calvados General Council, and the Ministry of Culture was developed. Didier Paillard and the Société Archéologique du Calvados directed a large portion of the later excavations. Excavation of the necropolis in its entirety was completed in 1994 (Paillard 2006).

The Michelet necropolis was likely the main cemetery used by the late Roman and Merovingian settlement of *Noviomagus Lexoviorum* and was located 250 metres from the city's 3rd century AD *castrum*. When it was established in the 4th century AD the necropolis was likely situated along a Roman road on a hilltop overlooking the city (Paillard 2006). Figure 2.2 illustrates the location of the Michelet necropolis in relation to the city's *castrum*, and an earlier necropolis, the Grand Jardin necropolis, dating to the 1st to the 3rd centuries AD. The earliest skeletal remains from the Michelet necropolis date to the first quarter of the 4th century AD and were oriented North-South. Beginning in the second quarter of the 4th century AD, and onwards, burials were oriented East-West. Approximately two thirds of the burials in this necropolis date to the 4th century AD, followed by a gap in use of the necropolis at the beginning of the 5th century AD. Burials resumed in the second half of the 6th century AD in smaller numbers during Merovingian rule and continued up until the 9th century AD (Paillard 2006). In total, skeletal remains from approximately 970 graves were excavated from the Michelet necropolis and are currently curated at the Université de Caen (Paillard 2006).

Figure 2.2- Location of Michelet Necropolis (Service Départmental d'Archéologie 2000:18)



The necropolis (Fig. 2.3) is made up of primary inhumations of both adults and subadults. There are a number of grave types at this necropolis: earth cut, wooden coffins (evidenced by iron nails deposited around the body), wedging stone burials, and combinations of the wooden coffin and wedging stone burials. A wedging stone burial is illustrated in Figure 2.4. There are also a small number of lead and stone sarcophagi that were recovered from the Michelet necropolis and are thought to date mainly to the second half of 7th century AD (Paillard 2006).

Figure 2.3 - Michelet Necropolis (Paillard et al. 2009:3)

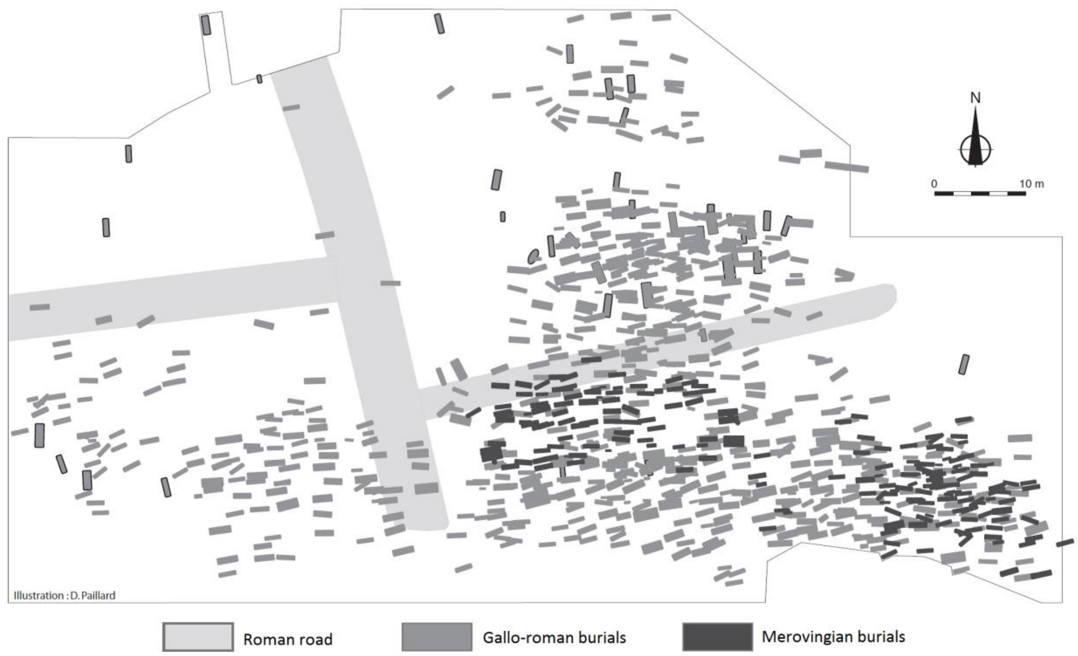


Figure 2.4 - Wedging stone burial MIC 42 (Université de Caen, retrieved June 2015)

Most individuals were buried without grave goods at Michelet. The grave goods that were recovered commonly included the remains of sandals, coins, and bracelets. Unfortunately, the ceramics in the necropolis were not recorded for each individual burial during excavation and cannot be considered in this study. At Michelet, there appears to be no differentiation between burial treatment of subadults or adults (Paillard 2006).

Paillard (2006) does note that although remains from Michelet are generally well preserved, there is evidence of looting at the site. This was most marked in 4th century AD burials, continued to a lesser degree in the following centuries, and likely occurred in antiquity. A large portion of the site was protected from modern disturbances as it was preserved under a paved courtyard; however, during excavation it was noted that the installation of a modern pipeline destroyed a small number of Merovingian sarcophagi (Paillard 2006).

2.4 Terminology Used for Individual Ages

Bioarchaeological literature uses a number of terms including; juvenile, infant, child, adolescent, and subadult, to refer to skeletally immature individuals, which becomes confusing when clear definitions are not established. Further complicating this matter, other disciplines use the same terms for immature individuals, but with differing definitions. Clear definitions for terms used in this study and a framework to understand age is provided.

Age can be conceptualized in three main ways; chronologically, physiologically, and socially. Chronological age is measured in time since birth; often expressed in years. When exact age at death is unknown in skeletal samples bioarchaeologists estimate approximate chronological age through physiological developments. Physiological age is the physical maturation of the body measured by bioarchaeologists through skeletal features including dental formation and eruption, epiphyseal appearance and fusion, and bone growth in length. Social age is defined as, “the culturally constructed norms of appropriate behaviour and status of individuals within an age category” (Halcrow and Tayles 2008: 192). One example of a social age category would be childhood. It is an age category that includes individuals who are physiologically immature, but its precise social meaning, expected behaviours, and implications vary across cultures and through time (Lewis 2007; Perry 2006; Gilchrist 2008).

Past bioarchaeological research often analysed individuals in age categories based on physiological development, frequently ignoring the social aspect of age, but as Halcrow and Tayles (2008) write, childhood is both a biological and social phenomenon and should thus be studied as such. Sofaer (2011) argues that with closer inspection of skeletal changes, including changes in disease frequency and type, or growth faltering in children bioarchaeologists can better understand the changing social roles and identity of children in the past.

This study analysed skeletal remains of individuals aged 0-12 years old. When discussing physiological changes in skeletal growth and development (timings that are linked to chronological age estimates) the term ‘subadult’ will be used. ‘Child,’ ‘children,’ or ‘childhood’ will be used in this text when discussing socio-cultural based notions of age.

2.5 Childhood

Children and the idea of childhood in the past became a topic of increasing importance during the 1990s stemming from the development of gender theory and the inclusion of feminist perspectives in archaeological interpretations (Lewis 2007). To better understand past childhood researchers employ a number of sources including skeletal remains, written records, depictions in art, and toys. Surviving historical documentation from the Roman period was mainly written from the perspective of the elite, literate male. When Roman authors did address children, the text was mainly directed towards other elite families, leaving information of daily life and childhood for those of the lower social classes invisible to modern historians (Harlow and Laurence 2002). Leyerle (2013) writes that with the rise of Christianity, surviving texts begin to focus more on everyday life with increasing mentions of children. These religious texts often discussed children's behaviours and games in order to illustrate and propagate religious teachings. It is debated, and ultimately unknown, to what degree the biases of ancient authors influenced the portrayal of childhood in the past. It should also be recognized that many documentary sources, written from adult perspectives, represent an ideal of childhood, and do not necessarily represent the realities of individual children's lives and the variation of different life trajectories (Lewis 2007; Callow and Harlow 2012).

2.5.1 Late Roman Childhood

Documentary evidence demonstrates that the Roman worldview considered individuals 0-7 years old *(infantia)* as vulnerable and in need of social and physical shaping in order to become a respected adults (Harlow and Laurence, 2002). For Roman babies swaddling was a common and encouraged practice (Rawson 2003; Croom 2010). After approximately two months of tight swaddling, the cloth was gradually loosened. The use of wet nurses during this period was common for elite Roman women (Rawson 2003). Soranus (2nd century AD) recommended gradual weaning with supplementation around two years of age; although, variation of weaning age within the Empire is likely (Rawson 2003).

At about the age of seven years Roman children officially entered the public sphere and were expected to gradually behave more like adults until the final transition to adulthood; at this stage children were considered to belong to the *puer* (male) or *puella* (female) age category (Harlow and Laurence, 2002). Quintilian, a Roman theorist in the 1st century AD, wrote that both boys and girls usually entered school around the age of seven years. For the elite families that could afford it, schooling took place in a variety of locations including large public buildings, the teacher's home, and children may also have been home schooled (Bloomer 2013; Vuolanto 2013).

Young Roman children likely dressed in clothing similar to adults; in northern Gaul many wore the Gallic coat (Croom 2010). The males wore the Gallic coat to approximately knee length, with sleeves extending to the elbows or wrist. The coat was often worn unbelted over a tunic, and sometimes with a scarf or a cape. For females, the Gallic coat was longer, usually mid-calf length with a longer, floor length tunic worn underneath. The tunic had sleeves covering up at least to the elbows or longer. In addition, females did not wear capes, but sometimes wore tight fitting hats or a mantle - a type of long scarf (Croom 2010).

Many opinions on the proper way to raise a child were expressed by Roman historians of the time, which included both praise and discipline to help the shape the child for adult life. Roman authors including Pliny, Horace and Seneca wrote about male children's activities including school, sports, fighting, and also that physical beatings were seen as acceptable forms of discipline (Harlow and Laurence, 2002; Redfern and Gowland, 2012; Vuolanto 2013). In a more extreme situation, a Roman law, *patria* *potestas,* gave the father the power to control his family members' lives and death if any were acting inappropriately (Harlow and Lawrence, 2002).

The next stage of the Roman life course began at the age of puberty; this was around 12 years for girls and 14 years for boys. Girls were then considered adults and eligible for marriage. Boys, on the other hand entered another stage of youth called *adulescens,* which lasted until they were approximately 25-30 years old (Harlow and Laurence 2002; Collins 2010).

2.5.2 Merovingian Childhood

As the decline of the Roman Empire was a slow process it can be postulated that to a certain degree ideas regarding childhood did not change drastically. There is at least some degree of cultural continuity in surviving texts regarding the stages of childhood through the collapse of the Western Roman Empire (Callow and Harlow 2012; Leyerle 2013). A number of early medieval writers divided childhood into similar categories to the Roman categories: *infans,* which include children up to seven years of age; the *puer* or *puella* followed and ended around the age of puberty, followed by *adolescens* (James, 2004). These social age categories are very similar to those documented during the Roman Empire. Historians during the Merovingian age similarly wrote that education and harsh discipline were controlled through the father and both were both considered beneficial for the developing child (Southon, 2012).

The writings of Gregory of Tours also demonstrate the increasing importance of Christianity in Merovingian Gaul. At least some communities in the 5th and 6th c. AD in

Gaul believed in the importance of baptising young children sometime after birth, and that Christian mothers who raised Christian children were afforded better protection from the many illnesses that occurred in childhood (James 2004; Leyerle 2013).Historians report that swaddling was common practice during the early Medieval period and weaning occurred any time between the ages of 1 to 3 years (Orme 2001). Clothing would likely have varied between social classes. Orme (2001) suggests that children may have worn a long shirt with leggings and an over-garment, which was sometimes belted. Girls likely would have worn longer coats than boys.

With the rise of Christianity some children were raised in a monastery or episcopal establishment; usually, children older than six or seven years were accepted into these communities, as it was at this age that they could learn to read and obey leaders (James 2004). Not all children at this time were put in monasteries; some children attended school, some aristocratic boys were sent to another household to train as warriors, and many other children began to labour on their parent's farms or industries (James 2004). Leyerle (2013) writes that, at home or in monasteries, children were expected to help with chores including garden work, fetching water, or wood, and cooking. Children played a variety of games; boys often skipped stones, played with knucklebones, played pretend soldiers, and girls often played with dolls (Leyerle 2013). Gender roles were ingrained early in childhood with girls expected to help with their mothers' duties around the home, and boys were expected to participate and help in their fathers' trades (Leyerle 2013). Leyerle (2013) also notes that for destitute families, the debts of parents were sometimes paid through the loaning or selling of their children for labour, and child slavery was often mentioned in hagiographical texts during this period.

After the age of seven children were expected to start behaving more like adults, and following puberty Merovingian children became adults and were considered ready for marriage (James 2004). These strictly defined age categories described from the Roman and Merovingian periods provide a model of expected age-related behaviour, but it should be noted that social reality allows for more individual variation and does not always directly translate into social reality (Callow and Harlow 2012).

2.6 Conclusions

The biocultural perspective supports the notion that childhood is both a biological and cultural phenomenon. In the current study, biological processes of growth and disruption of growth are examined in the context of culturally specific ideas regarding childhood, as well as overarching social, political and economic disruption relating to the fall of the Roman Empire and establishment of Merovingian kingdoms. Specifically, patterns in the timing of growth delay and stunting, disruption of cortical thickness acquisition, assessment of body mass for age, and distribution of rickets from the late Roman and Merovingian city in northern Gaul, are analysed and interpreted within the specific cultural contexts and age associated behaviours.

Chapter 3: Background - Osteological Context

3.1 Introduction

This chapter will focus on outlining the processes of bone growth and development in the immature skeleton relevant for this study, specifically; longitudinal bone growth, appositional bone growth, attainment of cortical thickness, estimation of body mass, and the skeletal evidence for rickets. The consequences of metabolic stresses including malnutrition and vitamin D deficiency on these processes will also be considered.

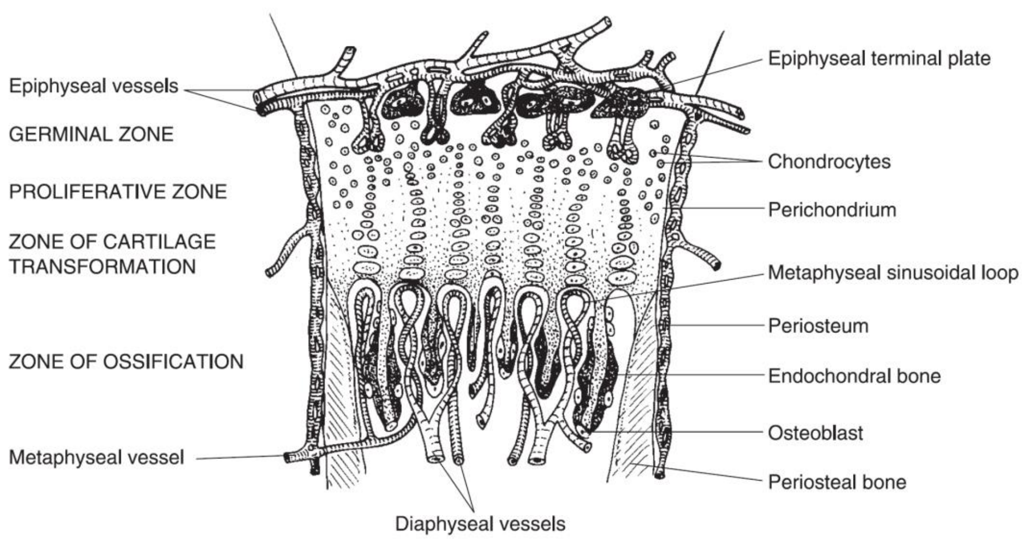
3.2 Skeletal Growth, Development and Maturation

Human bone growth and development are well understood processes. Growth, defined as “a quantitative increase in size or mass” and development; “a progression of changes, either quantitative or qualitative, that lead from an undifferentiated or immature state to a highly organized, specialized, and mature state,” occurs most rapidly in immature individuals (Bogin 1999:18). The rate of growth can vary based on age, sex, as well as between and within populations; some of this variation is controlled by genetics. As is discussed below in further detail (Section 3.3), external environmental factors are also significant in determining the rate of growth, as well as the overall achievement of adult stature (Scheuer and Black 2004).

Generally, postnatal growth in humans occurs most rapidly during the period between birth and three years of age (Bogin 2001). Between the age of three to seven years old the rate of growth plateaus and height is only expected to increase approximately five centimeters per year, with the exception of the mid-growth spurt estimated to occur around six to eight years of age (Bogin 2001). The span between approximately seven years of age up until puberty is considered to be the period with the slowest rate of growth since birth (Bogin 2001). The adolescent growth spurt, around the age of 10 for girls, and 12 for boys, is the period when reproductive maturation occurs and is the last growth spurt before long bone epiphyses begin to fuse and adult stature is attained (Bogin 2001).

Bone growth and development occur through both endochondral and appositional processes. Endochondral growth takes place at the growth plates and is responsible for the longitudinal growth of the long bones. This process entails the formation of a cartilage model at the end of the growth plate, which is subsequently mineralized. Long bone growth plates are composed of different zones; the resting zone (or germinal zone), the proliferative zone, the hypertrophic zone (also called the zone of cartilage transformation), and the ossification zone (Scheuer and Black 2004) (Fig. 3.1). The resting zone is the area closest to the epiphysis and is composed of small, randomly organized chondrocytes (cells that make up the cartilaginous model). The proliferative zone is located adjacent to the resting zone. In this zone, the chondrocyte cells are larger, multiplying by mitotic division, and arrange themselves in longitudinal pillar formations. In the hypertrophic zone chondrocytes become enlarged, and larger amounts of the inorganic component of bone, (hydroxyapatite) is incorporated into the matrix. In the next zone, the ossification zone, both osteoblastic and osteoclastic activity occurs. Osteoblasts create layers of bone on the cartilaginous model from the hypertrophic zone, as osteoclasts resorb bone to better organize the new bone structure (Scheuer and Black 2004). Eventually, the rate of mineralization will start to exceed the rate of growth of the cartilaginous model. Fusion of the growth plate and epiphysis occurs when the cartilaginous model is mineralized (Scheuer and Black 2004). Timing of epiphyseal fusion for the human skeleton is well documented, but shows considerable variation (Scheuer and Black 2004). For a more comprehensive review of human skeletal growth and development see Scheuer and Black (2004).

Figure 3.1 – Endochondral Growth in Long Bones (Scheuer and Black 2004:38)



In order to maintain the correct long bone proportions, appositional growth that increases the width of the diaphysis of the bone occurs in tandem with endochondral growth (Scheuer and Black 2004). Layers of new bone are deposited at the periosteal margin of the diaphysis as bone resorption occurs endosteally in the medullary cavity (Scheuer and Black 2004). The growth of the width of the diaphysis, as well as the resorption on the endosteal surface occur simultaneously, but for immature individuals the appositional growth occurs at a faster rate resulting in subadults attaining increasing thicknesses of cortical bone over time (Garn 1970; Mays et al. 2009b).

3.3 Growth Faltering

There are a number of indicators that demonstrate the impact of stress on the growing skeleton. Stress and health are vague terms used frequently in bioarchaeological literature (Reitsema and McIlvaine 2014). In the current study stress will be defined as, "a physiological change caused by strain on an organism from environmental, nutritional, and other pressures," (Reitsema and McIlvaine 2014: 181). Assessments of subadult growth and development remains one of the most researched and accepted methods of analysing the general health of past populations. Anthropological studies have demonstrated, since the early 20th century, that growth is the result of a complex interaction between genetics and the environment, of which nutrition and infection are key components (Saunders and Hoppa 1993; King and Ulijaszek 1999; Mays et al. 2009a,b). Despite many decades of in depth research, it is impossible to understand the impact of one factor alone on the growth of an individual. Further complicating matters, it is clear that factors including nutrition, disease, and immature immune systems can interact synergistically to influence growth faltering (King and Ulijasek 1999; Scheuer and Black 2004). Undernutrition, malnutrition, protein deficient diets, exposure to disease and infection, maternal malnutrition and immature immune systems are each cited as having potential negative effects on the achievement of stature, the slowing of the rate of growth, and delaying skeletal development (King and Ulikaszek 1999; Scheuer and Black 2004; Cardoso 2007; Mays et al. 2009b). It is also believed that the severity and duration of the stressful period impacts the degree of stunting or growth delay experienced (Saunders and Hoppa 1993).

Anthropological studies of children often measure stature as a key indicator of delayed growth for age. Many studies attempt to identify growth 'stunting'; defined as height two standard deviations below the 'normal' mean height for age of a healthy reference population (Malina et al. 2009). In archaeological remains, growth faltering is identified by comparing long bone diaphyseal lengths to dental age estimates (Hoppa and FitzGerald 1999). Dental development is used as a preferred method of estimating age in skeletal samples as the timing of these processes (mineralization and eruption) have been shown to be less affected by external factors than long bone growth, and thus are more representative of chronological age (Cardoso 2007; Conceição and Cardoso 2011). Growth faltering refers to a, "decrease in a growth velocity resulting from disruption of the normal growth process," (Humphrey 2003:145). A cross-sectional study of long bone diaphyseal lengths compared to dental ages creates a 'skeletal growth profile' (SGP) of the sample up until the age of epiphyseal fusion (Hoppa and FitzGerald 1999; Lewis 2007; Cardoso and Garcia 2009). Comparing the growth profile to modern growth trajectories, or between other archaeological populations, or between groups within a single population can identify possible patterns of growth faltering (Hoppa and FitzGerald 1999). Analysing cross-sectional growth data in comparison to longitudinal studies allows only for the recognition of average growth trends and does not reveal individual variations in the timing and extent of growth velocity (Humphrey 2003).

The evaluation of the ways in which growth disruptions and health interact in past populations is confounded by the osteological paradox (Wood et al. 1992). Saunders and Hoppa (1993) examined the biological mortality bias inherent in studying health and stress of a population based on the subadult non-survivors. They questioned whether growth data derived from subadult non-survivors can be representative of the growth patterns of those subadults who survived into adulthood (Saunders and Hoppa 1993; Hoppa and FitzGerald 1999). Saunders and Hoppa (1993) concluded in their study that although there does seem to be differences between the growth of survivors and non-survivors, this difference in skeletal samples would likely be negligible in comparison with other sources of error including methodological issues in age estimates (Saunders and Hoppa 1993).

Episodes of nutritional stress can temporarily slow growth. If adequate nutrition returns, then a phenomenon called ‘catch-up growth’ may occur. Catch-up growth is described as a rapid increase in growth velocity that occurs after recovery from disease or nutritional stress that resulted in stunted or slowed normal growth (Bogin 1999). If catch-up growth occurs, it is possible for subadults to attain the stature or size they would have reached had there not been a disruption in growth. Catch-up growth may hinder the ability to identify previous growth faltering in individuals who have recovered from a stressful period before their death (Bogin 1999).

3.3.1 Appositional Growth and Cortical Thickness

Recent studies (Pinhasi et al. 2006; Ruff et al. 2013) suggest using multiple skeletal indicators and measurements of growth to provide a more complete perspective on growth patterns in relation to nutritional stress. Appositional growth occurs at a faster pace than resorption during subadult growth. Thus normal growth would entail an increase in cortical thickness through subadult development (Garn 1970). Clinical studies have demonstrated increased endosteal resorption and reduced cortical thickness for age as a response to malnutrition in subadults (Ruff et al. 2013). This effect has also been documented in subadults from archaeological populations and attributed to nutritional stress (Keith 1981; Mays et al. 2009b). Mays et al. (2009b) analysed long bone lengths, as well as appositional bone growth and cortical thickness to better understand different ways in which growth faltering may be identified and which measure was the most sensitive to environmental factors. Bioarchaeological analyses of subadult skeletal remains demonstrated that cortical thickness is likely a more sensitive measure of metabolic stresses when endochondral growth has not been significantly affected or when the methodology is not sensitive enough to detect slight growth faltering (Hummert 1983; Mays et al. 2009b).

3.3.2 Body Mass

Weight for age and body mass index (BMI) of children are widely used in anthropological studies that examine population health (Malina et al. 2009). Body mass is another measure of growth known to correlate with health in modern populations (Ruff et al. 2013). Specifically, Bogin (1999) notes that improvements in nutrition and socio-economic status correlate with body size. This is supported by cross-sectional and longitudinal anthropological studies of body mass and BMI (Malina et al. 2009). Anthropological studies demonstrate that body size (stature and body mass) is relatively similar between different populations that have adequate nutrition throughout early development, suggesting that significant variations in body mass during early development reflect environmental and nutritional differences. Genetic influence is thought to have greater control over body size during adolescence (Frisancho et al. 1980; Ruff et al. 2013). Body mass estimations have been used less frequently in bioarchaeological studies due to a lack of established methods for estimating body mass from subadult remains. Ruff's (2007) work is the first study to develop age specific equations for estimating body mass in skeletal samples based on data from the Denver Growth Study.

3.4 Rickets

Vitamin D, more accurately described as a prohormone, is essential for, among other functions, the proper mineralization of bone during growth, bone remodelling, homeostasis of calcium within the body, and the regulation of the immune system (Holick 2008; Jokar et al. 2008). Vitamin D deficiency (a metabolic disorder) can result from insufficient cutaneous exposure to sunlight or insufficient dietary intake of vitamin D (Brickley and Ives 2008). Vitamin D synthesis occurs within the body primarily through cutaneous exposure to sunlight, and also in smaller amounts through dietary ingestion. Vitamin D is found in small quantities in foods including oily fish, eggs, fortified milk, and liver (Brickley and Ives 2008: 82). Dietary phytates, from cereal grains and found in unleavened breads, have been found to block calcium absorption further disrupting calcium homoeostasis within the body (Demay and Krane 2010; Pilkington 2013).

Rickets is defined as the failure to mineralize newly formed osteoid during growth preceding epiphyseal fusion (Dimitri and Bishop 2007; Markestad 2012; Shore and Chesney 2013). Osteomalacia is a term used for the improper mineralization of bone that is remodelling (Dimitri and Bishop 2007). Osteomalacia is most often identified in adults, but occurs in subadults as they are undergoing processes of growth and remodelling simultaneously (Markestad 2012; Shore and Chesney 2013). For consistency and clarity, in the current study the term rickets will be used to characterize vitamin D deficiency in skeletally immature individuals.

It has been estimated that at a minimum, infants need approximately two hours of sun exposure a week, while fully clothed, but without a hat (Brickley and Ives 2008). A more recent estimation of adequate exposure has been described for children and adults by Wacker and Holick (2013). They note that generally, children and adults can obtain adequate levels of vitamin D with approximately 50% of the amount of sunlight exposure needed for a mild sunburn (Wacker and Holick 2013). Individuals with darker skin pigmentations are at greater risk for developing vitamin D deficiency and require about five to ten times longer exposure times to sunlight to maintain adequate levels (Brickley and Ives 2008; Holick 2008). There are a number of rare genetic conditions that manifest in similar skeletal deformities. In archaeological samples though, where there are a considerable number of cases of vitamin D deficiency it is likely that most of these cases are a result of behaviours that limit sunlight exposure and influence dietary practices (Brickley and Ives 2008). The environment plays a large role in the amount of available ultraviolet light. Geographical latitudes and seasonal fluctuations in available sunlight limit the amount of potential sunlight exposure. Additionally, urban areas with tall architecture and heavy pollution limit the amount of sunlight that reaches ground level (Pettifor 2004).

Socio-cultural behaviours that limit skin exposure to sunlight are an important factor for the development of vitamin D deficiency. Clothing that covers skin and engaging in a predominantly indoor lifestyle are known to affect the development of vitamin D deficiency in modern populations (Jokar et al. 2008; Pettifor 2004). Low maternal levels of vitamin D directly impacts infant levels in utero and later through breast milk (Brickley et al. 2014). Additionally, child rearing practices including swaddling and prolonged breastfeeding without adequate supplementation can also contribute to the development of rickets (Miyako et al. 2005; Mustafa et al. 2007; Brickley et al. 2014). This combination of factors can result in increased likelihood of infants with more severe deficiencies (Pettifor 2004). Nutritional rickets, outlined in further detail by Pettifor (2004) and DeLucia et al. (2003), results primarily from vitamin D deficiency leading to decreased amounts of calcium absorbed by the body to be used for proper bone mineralization. Weaning foods that lack dairy further deprive the body of calcium to be used for bone mineralization, thus contributing to more severe manifestations of rickets (DeLucia et al. 2003).

3.4.1 Manifestation of rickets

This section will only focus on the manifestations of rickets, as an in depth understanding of the expression of vitamin D deficiency in adults is not pertinent for this study. Clinically rickets is diagnosed using blood tests to evaluate levels of 25-hydroxyvitamin D (25-OHD, also called calcidol) in blood serum (Thacher et al. 2006; Dimitri and Bishop 2007; Jokar et al. 2008). Iliac crest biopsies are also an effective way of quantifying the amount of un-mineralized osteoid, but are not standard practice as it is a more invasive procedure (Jokar et al. 2008). Radiographs and patient histories of diet and sunlight exposure are also used to confirm diagnoses (Thacher et al. 2000; Miyaki et al. 2005). In skeletal archaeological remains diagnoses of probable cases of rickets are based on a number of criteria, derived from clinical and bioarchaeological observations (Ortner and Mays 1998; Mays et al. 2006; Pinhasi et al. 2006; Brickley and Ives 2008).

Deficient vitamin D results in a failure to adequately mineralize newly formed osteoid, eventually leading to the softening of bones and morphological deformities in weight bearing bones for subadults (Pinhasi et al. 2006; Brickley and Ives 2008). Mays et al. (2006) outline a number of macroscopic and radiographic features caused by vitamin D deficiency identifiable in skeletal remains that are examined in more detail in section 4.8.1 and 4.8.2.

Active and healed cases are also distinguishable in archaeological remains (Mays et al. 2006). Active cases are identified based on the presence of porous or roughened growth plates, or porosity of the cortical bone in cranial or post-cranial elements where unmineralized osteoid would have been located (Mays et al. 2006; Brickley and Ives 2008). Clinicians note that metaphyseal flaring and growth plate abnormalities are able to heal within several months after adequate vitamin D levels in the body are attained, but complete remodelling of bowed long bones takes much longer (Thatcher et al. 2002).

3.4.1.1 Macroscopic Skeletal Features of Rickets

The initial changes that occur in rickets are metaphyseal flaring and cupping of the distal growth plates (Brickley and Ives 2008) (Fig. 3.2). This is caused by the slow accumulation of poorly/unmineralized cartilage at the metaphyses which then begins to spread under weight bearing (Shore and Chesney 2013). Distal growth plates of long bones also exhibit a rough or velvety texture (Fig. 3.3). Ortner and Mays (1998) initially created a numbering system that characterizes the severity of the porosity on the growth plate and Mays et al. (2006) revised this division with an extra step of pathological change demonstrated in more subtle or early cases of deficiency. Long bones can also demonstrate a general thickened appearance (Ortner and Mays 1998). Costochondral rib ends can also appear thickened, flared, cupped and can exhibit porosity. Abnormal acute curvature of ribs can also be visible in skeletal remains (Ortner and Mays 1998; Mays et al. 2006; Brickley and Ives 2008). Long bone bending is the most widely recognized feature of rickets. Bending can occur in the long bones of the arms and legs, though bending in the legs is observed more frequently than arm bone bending (Mays et al. 2006). These deformities result from weight bearing on soft bones during walking and crawling. *Coxa vara* is used to describe the bending of the femoral neck (Mays et al. 2006) (Fig. 3.4). *Genu varum* (lateral bending) and *genu valgum* (medial bending), colloquially referred to as 'knock-knee,' are used to describe deformities that affect the distal femur and proximal tibia (Shore and Chesney 2013). Mays et al. (2006) also identified flattening of the femoral head in skeletal remains as a result of rickets. Porous, plaque-like deposits found on the concave sides of bowed long bones is also a feature of rickets observable in skeletal remains (Mays et al. 2006). Ortner and Mays (1998) observed concave deformity of the ilium resulting from weight bearing on soft, poorly mineralized bone.

Figure 3.2 Metaphyseal flaring of distal femora MIC 95

Figure 3.3 Distal femoral growth plates demonstrating 'velvety' texture, score of 1 (MIC 234)

Figure 3.4 Coxa vara (inward bending of the femoral neck resulting in a decrease of the angle between the neck and shaft) MIC 144

Cranial features linked to rickets include; plaque-like porous bone deposits, bossing, and orbital porosity; however, these features are non-diagnostic of rickets and can be a result of many other conditions (Ortner and Mays 1998). Mandibular deformity has also been noted in a small number of archaeological cases of rickets (Ortner and Mays 1998), but not in clinical cases. Medial or posterior bending of the mandibular ramus and condyle is thought to be caused by chewing action (Ortner and Mays 1998; Mays et al. 2006). It should be noted and considered that no one feature is pathognomic of rickets, but a number of features that appear together can be more suggestive of the presence of rickets (Brickley and Ives 2008).

3.4.1.2 Radiographic Features of Rickets

Radiographic features of rickets in archaeological skeletal remains are described by Mays et al. (2006) and Brickley and Ives (2008). Radiographic analysis of archaeological skeletal remains may be hindered by poor preservation and the presence of soils within the medullary cavity of the bone (Mays et al. 2006). In radiographic analyses of rachitic individuals, the most common feature observed is coarsening and diffuse osteopenia of the trabecular bone. This appears as dark areas of less mineralized trabeculae with a smaller number of thicker, more visible trabeculae (Fig. 3.5) This is due to finer trabeculae being completely demineralized or resorbed, with thicker, coarser trabeculae remaining (Mays et al. 2006). In some cases, demineralization of bone is present on the endosteal surface resulting in the loss of the sharp distinction between cortical bone and the medullary cavity (Mays et al. 2006). Cortical tunneling, a form of cortical demineralization, appears as “linear radiolucencies within the cortex, giving a longitudinally striated appearance," (Mays et al. 2006:367) Adaptation to mechanical forces can also be seen radiographically in long bones with bending deformities. When bending is present, the cortical bone may be thickened on the concave side, and in more marked cases of bending deformity, struts of bone spanning the medullary cavity may be identified (Mays et al. 2006). Features such as bowing and metaphyseal flaring that can be identified macroscopically are also visible on radiographs. Evidence of healing can also be observed radiographically at the metaphysis as normal bone growth resumes; normal trabeculae appear and the cortico-medullary distinction returns (Brickley and Ives 2008).

Figure 3.5 Coarsening and diffuse osteopenia of the femoral trabeculae (MIC 95 left and right femora in A/P position)

Chapter 4: Materials and Methods

4.1 Materials

This study aims to identify skeletal evidence for disruptions in normal growth and development, and the pattern or occurrence of rickets throughout childhood in the subadult population of *Noviomagus Lexoviorum*. Growth disruption and prevalence of rickets are also assessed in relation to burial type, between individuals with and without recorded grave goods, and between the two time periods. Permission from the Université de Caen was granted to analyse skeletal remains excavated from the Michelet necropolis in Lisieux, France. The collection is large, comprising 970 individuals, of which approximately 25% are under the age of 20 years (Paillard 2006) and date from the late Roman period (4^{th} – 5^{th} century AD) and the Merovingian period (7^{th} – 8^{th} century AD). Dating of the Michelet burials was originally assigned during the initial site analysis and current consensus remains that the burials date to these two periods, but a review of the dating is currently underway. Skeletal remains of 130 subadults (0-12 years of age) of varying preservation were analysed for this study. Information regarding grave type, grave goods, and date of each burial derived from stratigraphic sequences were retrieved from 'Ancienne École Michelet-Jules Ferry, Lisieux Calvados, Document Final de Synthése 1990-1993, Tome II' (Paillard 2006).

4.2 Data Collection

A number of macroscopic and radiological techniques were used to assess the growth and development of this skeletal sample. Data collection for this project took place at the Université de Caen over the course of six weeks during May and June of 2015. This research project is part of the SSHRC funded project - 'Social-Cultural Determinants of Community Wellbeing in the Western Roman Empire: Analysis and Interpretation of Vitamin D Status' directed by Drs. Brickley and Prowse. The research conducted involved the completion of macroscopic recording forms for each individual (provided by Drs. Brickley and Prowse), photography of various pathological conditions, and specifically for this study, radiography of teeth and long bones.

4.3 Dental Aging

Dental scoring following Gustafson and Koch's (1974) method based on mineralization and eruption of deciduous and permanent dentition, and was used as the primary method for aging. Gustafson and Koch's (1974) methodology was considered appropriate to establish dental ages in the Michelet subadults since the method was derived from a European sample. Each tooth was recorded as either present or absent, and the state of mineralization and eruption was documented. Both loose teeth as well as teeth still in situ in the mandible and maxilla were recorded and used for age estimation. As the number of teeth present for each individual varied widely, at least three teeth for each individual was required to calculate a confident and precise age estimate.

Portable digital radiographic equipment (Golden Engineering XR200 source and FlashX Pro Digital Detector Array) was made available through an agreement with the University of Montréal. Radiographs of dentition were used to provide more reliable age estimations with more precise age ranges. The tube to imaging plate height was set at

110cm. KVp values ranged from 18-28. The kVp value was adjusted for each radiograph based on bone preservation and density, as this ranged widely between neonatal and older subadult remains. Radiographs of dentition were generally taken using 26 kVp. Radiographs were taken of the right and left sides of the mandible and maxilla when available. Loose and in situ teeth were examined and recorded in the field while radiographs of in situ teeth were later examined in order to assess states of mineralization of the roots and tooth buds still in the crypt.

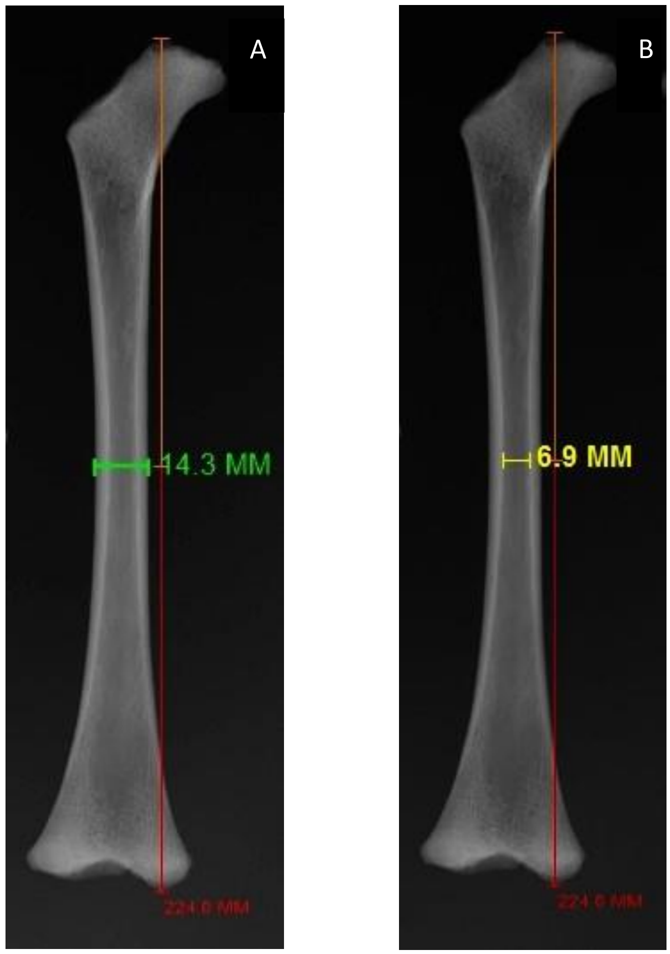
4.4 Diaphyseal Long Bone Length

Maximum length (mm) of complete long bones, with unfused epiphyses, was measured in the field using an osteometric board. Standards used for measuring maximum long bone lengths were followed using Buikstra and Ubelaker's method (1994). Both right and left long bone lengths were recorded when complete for the femora, tibiae, fibulae, humeri, radii, and ulnae. Using aging tables based on long bone lengths presented by Maresh (1970), skeletal elements were assigned an age estimate additional to, and unassociated with the dental ages. For each element, the left long bone was used to estimate age, unless it was absent or partial, in which case the right counterpart was used if available and complete. The Maresh (1970) dataset was chosen as an appropriate comparative reference sample for this study as precise measurements for the femur, tibia, humerus, radius and ulna were available for half year intervals, also the Maresh (1970) data are frequently used in other bioarchaeological growth studies allowing for inter-site comparisons.

4.5 Appositional Growth and Cortical Thickness

Another method of assessing nutritional stress involves measuring appositional growth and cortical thickness. It has been suggested that these measures may be more sensitive indicators of stress compared to endochondral growth (Mays et al. 2009b). In this study appositional growth and cortical thickness were measured using radiographs at the mid-shaft of the following long bones: femora, tibiae, humeri, radii and ulnae. The fibula was not included as it was considered less robust than other long bones and was less likely to preserve intact. For each individual the left sided bone was used for measurement when available and complete, and the right sided bone was used in cases when the left was missing or incomplete. The bones were placed in anterior/posterior (A/P) positions or in some cases posterior/anterior (P/A) positions when needed to ensure that the bone laid flat against the imaging plate, reducing the amount of distortion in the image. A one inch calibration ball was placed on each plate in order to correct for parallax when taking measurements. Radiographs of postcranial remains were taken with kVp values ranging from 18 - 28. In order to capture the best possible resolution and contrast with the cortical bone and medullary cavity, kVp values were adjusted based on bone preservation and density, as this ranged widely within this collection of neonatal to older subadult remains. Medio-lateral mid-shaft widths were recorded in mm. Cortical thickness was calculated by subtracting the medullary width from the medio-lateral width for each bone following Mays et al. (2009b). Locations of these measurements used for this study are demonstrated in Figure 4.1.

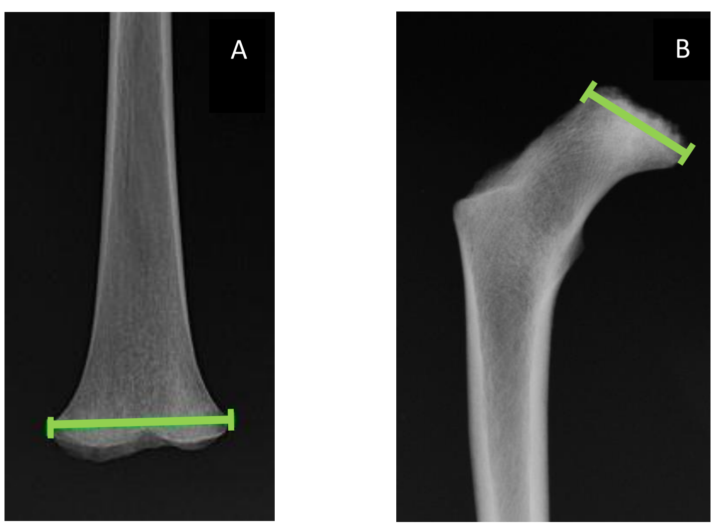
Figure 4.1. Measurement location for mid-shaft medio-lateral width (A) and medullary width (B) on MIC 331 right femur positioned P/A in the radiograph



4.6 Body Mass Estimation

Body mass estimations are used in this study to examine body size within the skeletal sample. Clinical studies and the WHO have demonstrated that subadult body size and development can be used as indicators of general health, nutrition, disease and environmental disturbances within and between populations (WHO 1995). Ruff's (2007) method uses femoral measurements and age specific regression equations for estimating body mass and can be used for 1-17 year olds. Ruff's (2007) methodology uses two different femoral measurements to estimate subadult body mass. Femoral distal metaphysis breadth is the first measurement that Ruff (2007) developed equations for and he advocates that this measurement is more precise for those individuals 1-7 years of age (Fig. 4.2A). The second is measurement is the femoral head breadth (diameter) and it is used to estimate body mass for the older children and adolescents (Fig. 4.2B). After the age of approximately 7 years, the femoral distal metaphysis breadth becomes less tightly connected with increasing body mass in subadults and wider error margins are expected (Ruff 2007). In the current study, body mass estimates for subadults under 7 years of age were calculated using the femoral distal metaphyseal breadth method, and for subadults 7 years and older body mass was estimated using only the femoral head breadth method.

Figure 4.2, A) Femoral distal metaphyseal breadth measurement B) Femoral head breadth measurement



Femoral distal metaphysis and head breadth measurements were taken (mm) from radiographs with Vidisco software using only complete femoral distal metaphyses and head breadths. The left femoral head and metaphyseal breadth was preferred for measurement, but the right was used as an alternative when the left was not present or was incomplete. Age dependent linear regression equations for each year from ages 1-12 years were used to estimate living body mass. Ruff (2007) notes that an age specific equation can be applied to an individual ± 0.5 year from the specified age of the equation. For example, regression equations for body mass for 5 year olds are applicable to individuals aged 4.5-5.5 years. In this study when an individuals' estimated dental age range spanned more than one year, the midpoint or average dental age of the individual was used in the calculation of body mass. For example, if an individual was determined to be 10-12 years old at death based on dental aging methodology, the formula for an 11 year old would be applied to this individual. An example of the calculation is demonstrated in Equation 4.1.

Equation 4.1 Body Mass Calculation Using Femoral Distal Metaphyseal Breadth for MIC 51

<u>Femoral distal metaphyseal breadth:</u> 50.4mm

<u>Age:</u> 5.5-6.5 years (equation for 6 year olds will be used)

Body mass estimate (Kg) = Intercept + (femoral distal metaphyseal breadth mm) X (Slope)

= -0.4 + 50.4 x 0.376

=18.6 Kg

** Age specific values for intercept and slope are found in Ruff (2007)*

4.7 Methodology for Estimating Growth Disruption

Studies have confirmed that dental ageing, although affected to a small degree by environmental perturbations, is a more accurate representation of chronological age than age estimates based on skeletal growth and development (Conceição and Cardoso 2011). Thus, longitudinal growth delay is identified in this study through a comparison of dental age estimates to age estimates derived from long bone lengths. Significant discrepancies between the two aging techniques signal the presence of growth stunting in the skeletal sample. Comparisons of long bone length for age between the Michelet sample, a healthy reference sample (Maresh 1970), and three other archaeological samples will also contextualize the pattern of growth in the Michelet sample.

Growth disruption of appositional growth (AP) and cortical thickness (CT) were assessed by comparing AP and CT to dental age. Data that presented as outliers and age categories with highly variable CT and less variable AP were used as indications of growth disruption. Body mass estimates were also plotted according to dental age, and outliers identified. Data regarding healthy weight for age standard from the WHO (2006) for individuals 0-5 years of age were compared to the Michelet subadult estimates to see if there was a difference between the healthy standard and the Michelet subadults. Growth disruption for long bone length, appositional growth, cortical thickness and body mass estimates were then further compared between individuals recovered from the Michelet necropolis from the late Roman and Merovingian time period, individuals recorded with and without grave goods, and those in different burials types.

There is some debate whether modern reference samples are appropriate for comparison to past skeletal populations. Schillaci et al. (2012) conducted a study to determine if the Maresh growth reference standard of healthy children from Denver, Colorado, is applicable to compare to diverse populations. Their study compared the Maresh sample with the WHO international child growth standard, which was created to represent growth in children worldwide regardless of ethnicity or socio-economic status. They demonstrated very close similar growth trajectories between the two samples (Schillaci et al. 2012). Although the growth trajectories were very similar, Schillaci et al. (2012) concluded that there were discrepancies between the estimation of stunting prevalence when the WHO and the Maresh (1970) data were used to as a reference standard for calculations of z scores. Thus, caution should be taken when comparing stunting prevalence in studies using different reference standards (Schillaci et al. 2012).

4.8 Pathology: Diagnosing Rickets

The current study included macroscopic and radiographic examination of skeletal remains to identify evidence of vitamin D deficiency in this sample. Previously published criteria outlined by Mays et al. (2006) were used in order to assess macroscopic pathological features associated with rickets. Radiographic analyses of post cranial remains also aided in diagnosing the presence of vitamin D deficiency in the Michelet subadults.

4.8.1 Macroscopic Assessment

Macroscopic analyses of cranial and postcranial remains were conducted and recorded using pathology forms (see Appendix B), from the SSHRC project directed by Drs. Brickley and Prowse. A total of 16 pathological features outlined by Mays et al. (2006) were assessed for this study; each feature was weighted on the diagnostic strength following designations outlined in Schattman (2014) (Table 4.1). Pathological features were scored as either present, absent, or not preserved. Individuals in this study were diagnosed as exhibiting a **probable** case of rickets when four or more pathological features were present in an individual, and at least one feature was a ‘probable’ feature. **Possible** cases of rickets were identified when one ‘probable’ feature was present along with one or two other ‘possible’ features, or when three possible features were present. When only one or two possible features or a number of non-diagnostic features were present, it was determined that there was insufficient evidence to make a confident diagnosis. The probable and possible cases were subsequently distinguished as either active or healed at the time of death following the criteria outlined by Mays et al. (2006). The case was determined to be active if the growth plates exhibited a roughened, porous or velvety texture, and in a state of healing if the distal growth plates were smooth (Mays et al. 2006). For each individual exhibiting pathological features characteristic of rickets, a differential diagnosis was conducted by ruling out a number of conditions and diseases that may exhibit similar features, as outlined in Brickley and Ives (2008).

*Table 4.1 Summary of Macroscopic Features Found in Rachitic Subadults***

Probable	Possible	Non-Diagnostic
• Deformed arm bones • Deformed leg bones • Coxa vara • Superior flattening of the femoral metaphysis • Long bone general thickening • Costochondral rib flaring with cupping • Porosity/roughening of distal growth plate (Score 2-4)	• Deformed mandibular ramus • Rib deformity • Costochondral rib flaring or porosity • Illium concavity • Long bone concave curvature porosity • Long bone metaphyseal flaring • Porosity/roughening of distal growth plate (Score 1)	• Frontal bone bossing • Cranial vault porosity • Orbital roof porosity • Long bone metaphysis porosity • Rib porosity

** Features outlined in Mays et al. (2006)

4.8.2 Radiographic Assessment

Radiographic analysis of long bones was undertaken for this study to help confirm and strengthen diagnoses of vitamin D deficiency based on macroscopic analyses. The current study assessed four radiographic features characteristic of vitamin D deficiency which are outlined by Mays et al. (2006). A summary of these radiographic features can be found in Table 4.2.

*Table 4.2 Summary of Radiographic Features Found in Rachitic Subadults***

Radiographic Features of Rickets
• Trabecular coarsening/thinning • Loss of cortico-medullary distinction • Cortical tunnelling • Biomechanical alterations

** Features outlined in Mays et al. (2006)

Chapter 5: Results

5.1 Introduction

A number of variables were compared for this study to better understand possible growth disruptions at Michelet. Dental ages, long bone lengths, appositional growth and cortical thickness, as well as body mass estimations for individuals 1-12 years old were analysed in order to distinguish trends in growth. Evaluations of growth between Roman and Merovingian individuals recovered from Michelet, individuals with different grave types, and those recovered with or without grave goods were examined statistically to see if patterns emerged. Comparisons of growth between a healthy, modern sample of children from Denver, Colorado, documented by Maresh (1970) and individuals recovered from the Michelet necropolis were made to determine if growth delay or stunting was present in the archaeological sample and to what degree. Femoral length data were also compared to three other archaeological skeletal samples recorded by Mays et al. (2008) and Saunders et al. (1993). Individuals with macroscopic and radiological evidence of rickets were also assessed to determine if any growth disruptions were evident and how they compared to other individuals in their age cohort at Michelet.

5.2 Descriptive Statistics

Data from this study were analysed using IMB Statistics 20 software. The program was used in order to calculate descriptive statistics, correlation tests, regression analyses, and z scores, and standardized residuals. Raw data for each individual regarding dental recording, bone measurements, and pathological features of rachitic individuals recording are available in the Appendices.

5.3 Study Sample Overview

To summarize the mortuary profile and increase sample sizes for analysis, the study sample was divided into four age groups; individuals aged 0-3 years, 3-6 years, 6-9 years, and 9-12 years. Tables 5.1 and 5.2 present the distribution of the late Roman and Merovingian individuals included in the growth and development study.

Table 5.1 Demographic Profile of the late Roman Subadult Sample Used in This Thesis

Age Category	Total number of individuals	Percentage (%) of Sample
0-3 years	9	21.4%
3-6 years	16	38.1%
6-9 years	7	16.7%
9-12 years	10	23.8%
	42	100%

Table 5.2 Demographic Profile of the Merovingian Subadult Sample Used in This Thesis

Age Category	Total number of individuals	Percentage (%) of Sample
0-3 years	5	27.8%
3-6 years	8	44.4%
6-9 years	4	22.2%
9-12 years	1	5.6%
	18	100%

A large proportion (70% or N= 42/60) of the sample is made of up late Roman (4th – 5th century AD) individuals. This is consistent with Paillard's (2006) conclusion that the majority of the necropolis is comprised of late Roman burials. In both the late Roman and Merovingian samples, the largest represented age category is the 3-6 year age group. The smallest portions of the sample comprised of the 6-9 year and 9-12 year subadults, with the exception of the 0-3 year category of late Roman subadults.

Risks associated with childbirth, introduction of weaning foods and vulnerable infant immune systems meant that infant mortality would have been quite high during the Roman, and likely Merovingian period (Todman 2007). Pilkington also notes that populations experiencing high rates of stunting also experience higher rates of infant and child mortality than populations that follow or exceed the healthy reference standard of growth (2013). It would be expected then that the 0-3 age category would be the largest category to reflect these risks. The lack of a larger sample of infant remains may be due to a preservation bias, recovery bias, or differential burial practices at Michelet for infants. Infant bones are smaller and less mineralized than more robust adult bones, and are thought to be less likely to be preserved and recovered during excavation (Carroll 2011).

Figure 5.1 presents the frequency of burial types between the late Roman and Merovingian time periods. Additionally, only six individuals of the 60 (10%) analysed in this study had recorded grave goods (Figure 5.2). All of the individuals that were recovered with grave goods are thought to date to the late Roman period (Paillard 2006). A Roman coin and vial were found with the two youngest individuals with grave goods, and fragments of bracelets, beads and a ring were found with older individuals (older than

4 years). Contextual information regarding individual burial type, date of burial, and presence/absence of grave goods is available in Appendix A, Table 9.

Figure 5.1- Frequency of Burial Types by Time Period

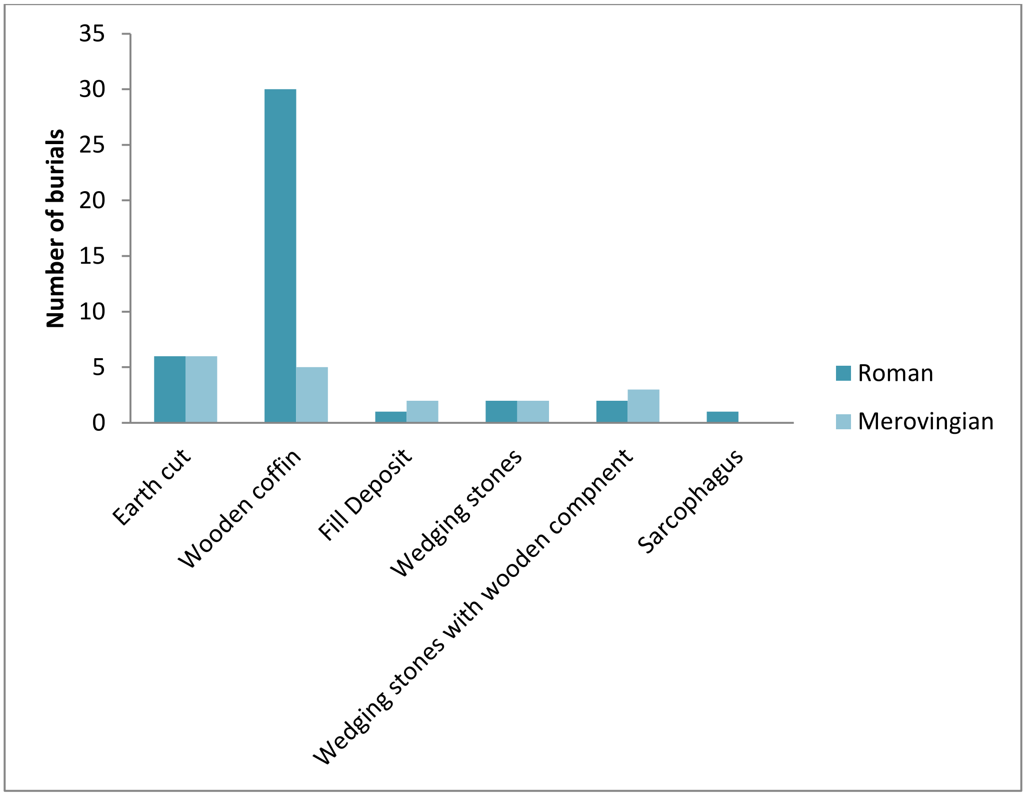
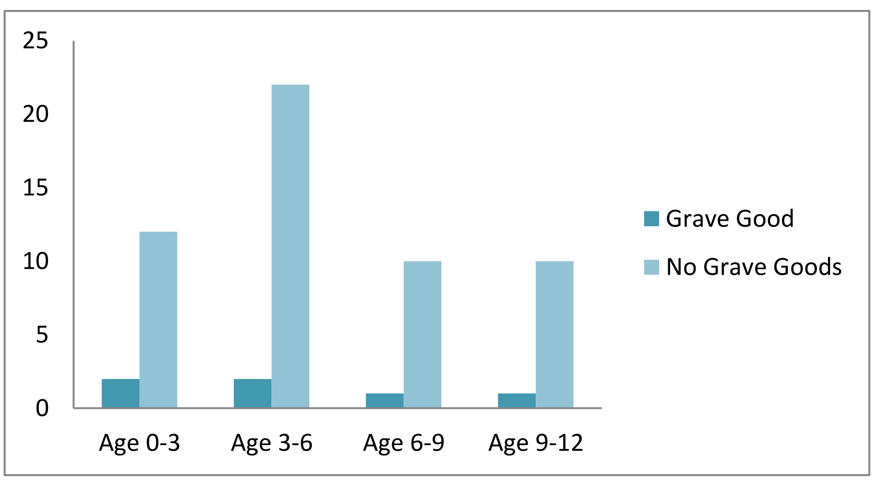


Figure 5.2 – Presence/Absence of Grave Goods by Age Category



5.4 Long Bone Length

Skeletal growth profiles (SGP) were created by plotting long bone length for the femur, tibia, humerus, radius and ulna against dental age estimates in Figures 5.3 – 5.7 below. The SGPs show a strong, linear relationship between dental age and long bone length. Pearson's correlation coefficient tests were conducted with dental age as the independent variable and long bone length (for the femur, tibia, humerus, radius and ulna separately) as the dependent variables, in order to confirm and characterize the strength of the relationship between long bone length and dental age. Assumptions of the data set regarding linearity, normality and homoscedasticity were met. R values (Table 5.2) range from 0.947 to 0.953 (all rounded to 0.95) demonstrating that there was a strong, positive linear relationship between long bone length and dental age significant at the 95% confidence interval ($p<.001$).

Figure 5.3 - Scatterplot – Femur Length vs. Dental Age

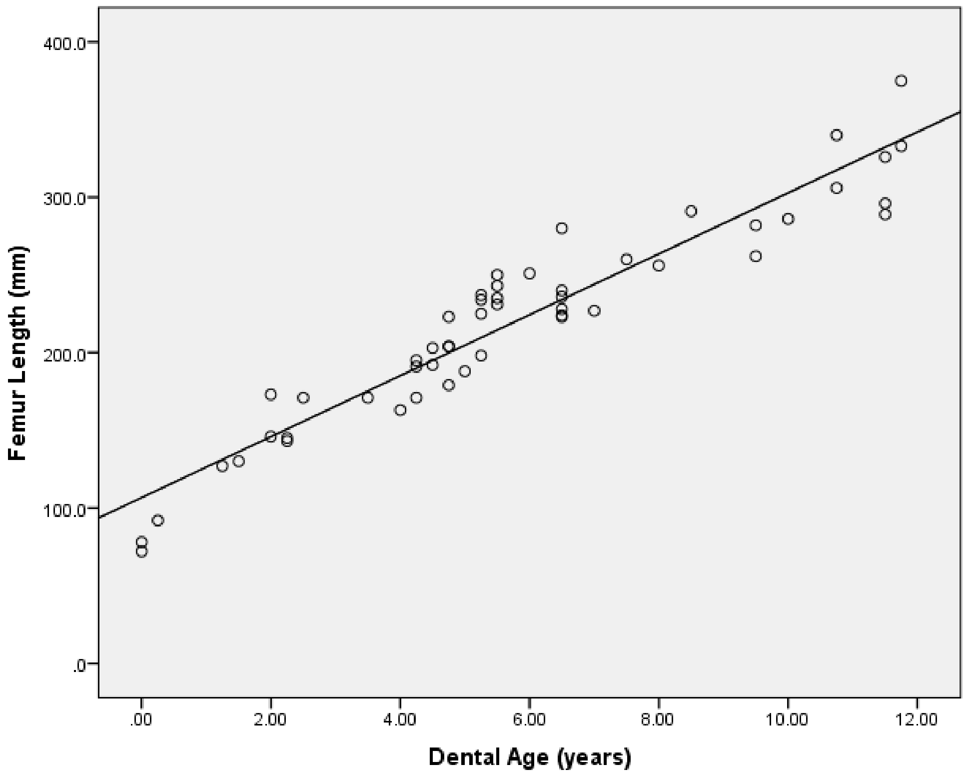


Figure 5.4 - Scatterplot – Tibia Length vs. Dental Age

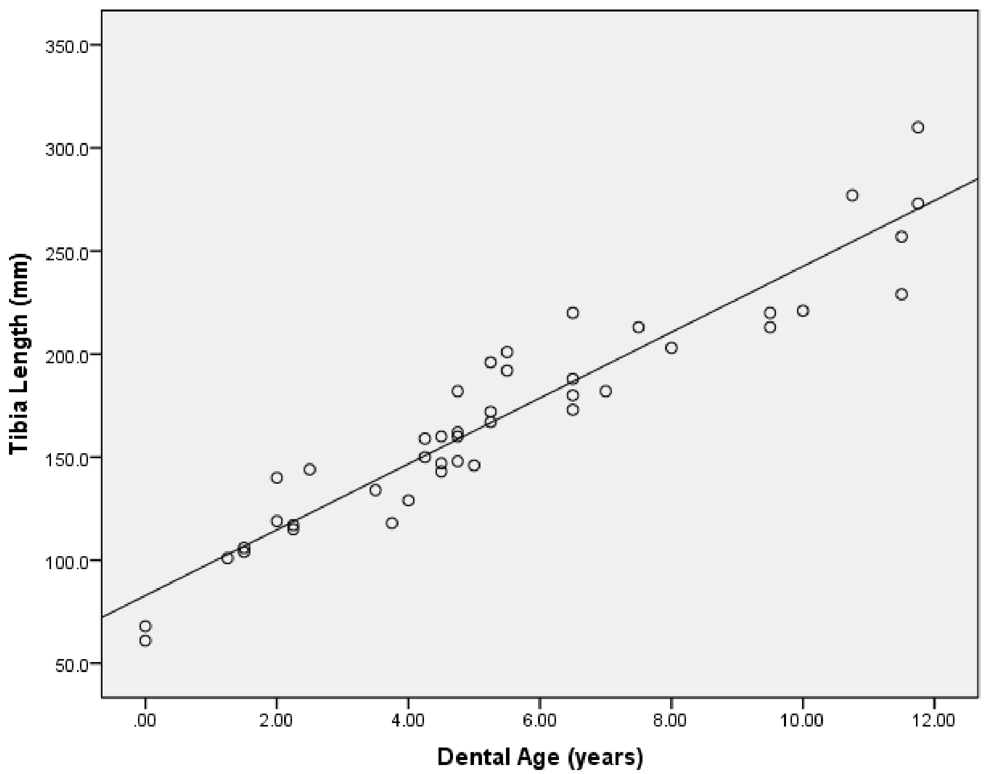


Figure 5.5 – Scatterplot – Humerus Length vs. Dental Age

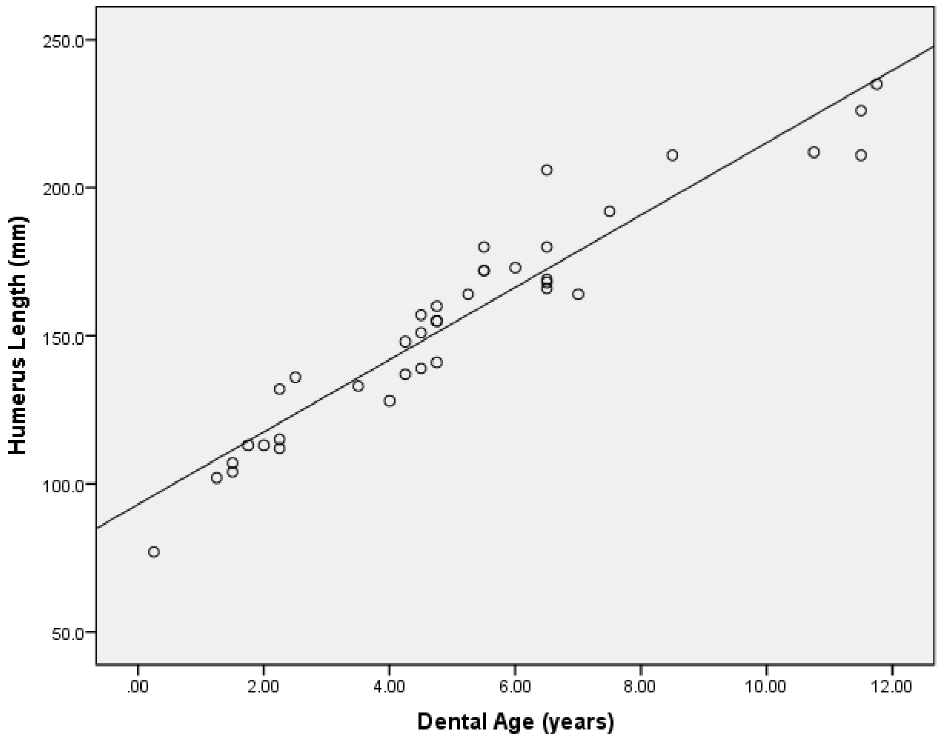


Figure 5.6 – Scatterplot – Radius Length vs. Dental Age

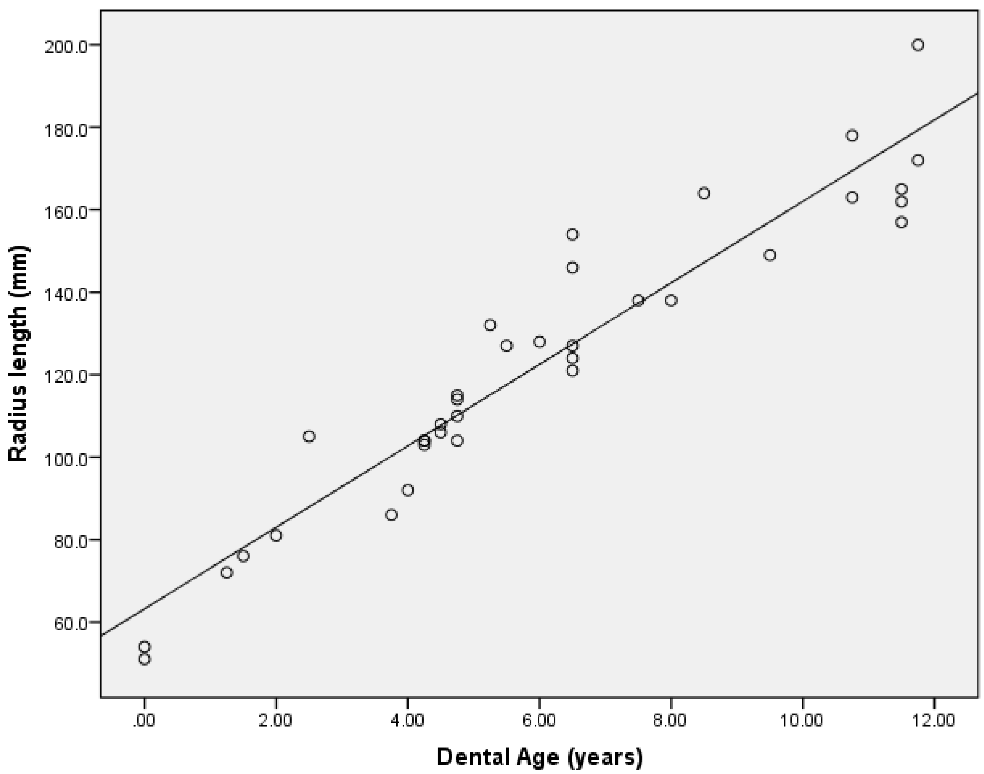


Figure 5.7 – Scatterplot – Ulna Length vs. Dental Age

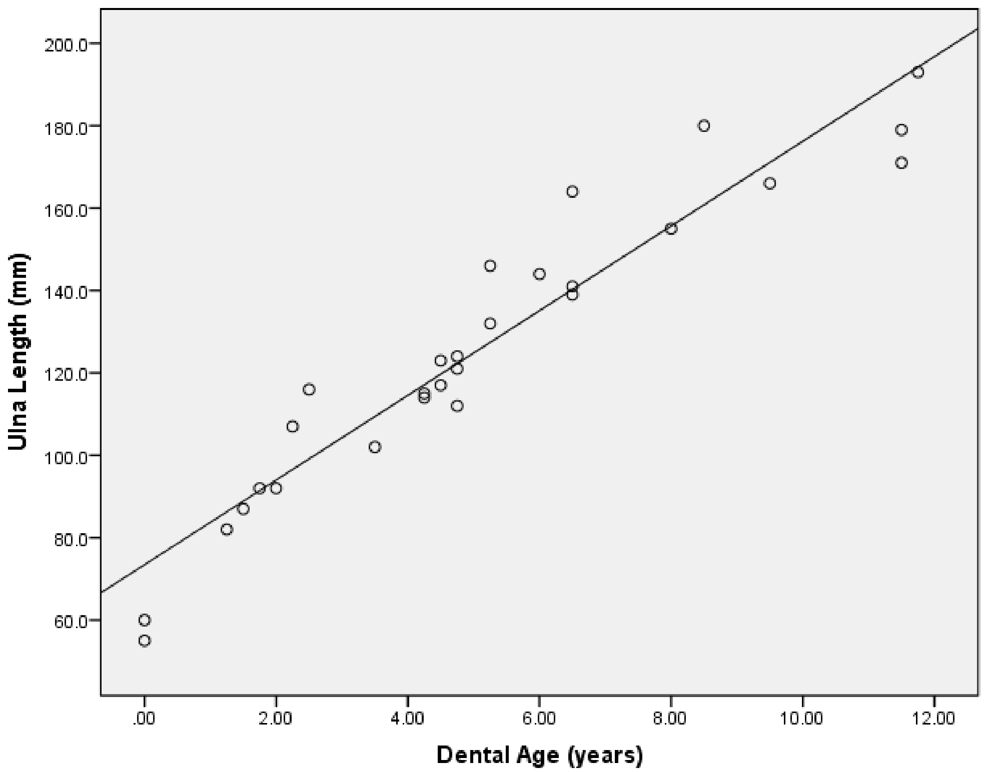


Table 5.3 – Pearson's Correlation Coefficient (R) Values – Long Bone Length vs. Dental Age

	Femur length vs. Dental Age	Tibia Length vs. Dental Age	Humerus Length vs. Dental Age	Radius Length vs. Dental Age	Ulna Length vs. Dental Age
R	0.95	0.95	0.95	0.95	0.95

* R, Pearson's Correlation Coefficient

To determine if there were differences in bone length for age between individuals buried during the late Roman and Merovingian period, a hierarchical multiple regression test was conducted using long bone length as the dependent variable, dental age as the first independent variable and date of burial (4^{th} – 5^{th} century AD or 7^{th} – 8^{th} century AD) as the second independent variable. Assumptions of the data set including, linearity, normality, multicollinearity, singularity, outliers, and homoscedasticity were met. The addition of burial date as an independent variable did not significantly contribute to the observed variation (Sig. F change = .21). The multiple regression analyses conducted on the tibia, humerus, radius and ulna revealed similar, non-significant results (Table 5.4). Another hierarchical multiple regression test was conducted to see if the influence of grave good presence/absence contributed to the observed variation of long bone length. Results demonstrated that the Sig. F change was not statistically significant (Table 5.5).

Table 5.4 Hierarchical Multiple Regression Sig. F Change Values – Addition of Burial Date

	Femur length vs. Dental Age	Tibia Length vs. Dental Age	Humerus Length vs. Dental Age	Radius Length vs. Dental Age	Ulna Length vs. Dental Age
R^2 Change	0.00	0.00	0.00	0.00	0.00
Significant F Change	0.19	0.67	0.52	0.62	0.94

Table 5.5 Hierarchical Multiple Regression Sig. F Change Values – Addition of Grave Good Presence/Absence

	Femur length vs. Dental Age	Tibia Length vs. Dental Age	Humerus Length vs. Dental Age	Radius Length vs. Dental Age	Ulna Length vs. Dental Age
R^2 Change	0.00	0.00	0.00	0.00	0.00
Significant F Change	0.84	0.64	0.76	0.64	0.75

A third set of hierarchical multiple regression tests were conducted to determine if grave type contributed to some of the variation of long bone length. Individuals analysed in this study were buried in earth cut graves (N=13), wooden coffins (N=34), wedging stone burials (N=4), burials with wedging stones and some kind of wooden component (N=6), a sarcophagus (N=1), and a few individuals were found in fill deposits (N=2). Those buried in wedging stone burials with and without some type of wooden component were combined in order to create a larger sample size (N=10). Linear regression analyses were not calculated for those found in fill deposits, nor for the individual who was recovered from a sarcophagus due to small sample size. There was no statistically significant difference when grave type was added to the model (Table 5.6).

Table 5.6 Hierarchical Multiple Regression Sig. F Change Values – Addition of Grave Type

	Femur length vs. Dental Age	Tibia Length vs. Dental Age	Humerus Length vs. Dental Age	Radius Length vs. Dental Age	Ulna Length vs. Dental Age
R^2 Change	0.00	0.00	0.00	0.00	0.00
Significant F Change	0.86	0.57	0.86	0.36	0.92

To assess potential discrepancies between overall growth trajectories of individuals buried in different grave types, with or without grave goods and between the late Roman and Merovingian time periods, an analysis of covariance (ANCOVA) was performed to test the homogeneity of regression slopes. Bone length was used as the dependent variable, date, grave good presence/absence, and grave type was used as the grouping factor, while controlling for the influence of dental age as the covariant (Table 5.7). A significant difference was found for the ulna when date was introduced as a predictor variable at the 95% confidence interval. Although the statistical test found this result significant, it would be expected that if there were real differences in subadult growth between the late Roman and Merovingian period significant results would be obtained for more than one of the long bones. As all other comparisons between long bone lengths from each period were not significant, it can be concluded that no real differences in the growth of long bones between the two periods existed.

Table 5.7 – ANCOVA tests for Homogeneity of Slopes

	Date			Grave goods			Grave Type		
	Sig.	df	F	Sig.	df	F	Sig.	df	F
Femur length vs dental age	0.41	1	0.68	0.92	1	0.01	0.21	3	1.58
Tibia length vs dental age	0.56	1	0.35	0.48	1	0.51	0.14	2	2.07
Humerus length vs. dental age	0.19	1	1.79	0.58	1	0.31	0.86	2	0.15
Radius Length vs. dental age	0.10	1	2.96	0.89	1	0.02	0.51	2	0.69
Ulna length vs dental age	.001	1	13.97	1.00	1	0.00	0.06	2	3.18

** Sig., statistical significance value; df, degrees of freedom; F, F statistic

5.4.1 Delayed Skeletal Growth

To determine if the subadults buried in the Michelet necropolis had experienced growth delay, age estimates derived from dental formation and eruption were compared with age estimates derived from long bone lengths for each individual (Figs. 5.8 – 5.12). Age estimates based on long bone length were consistently lower than dental age estimates, demonstrating that long bone growth was delayed for many individuals. It appears from the aforementioned scatterplots that after approximately two years of age larger differences in dental versus long bone length age estimates occur, while for individuals younger than two years of age long bone length and dental age estimates were much closer.

Figure 5.8 – Scatterplot of Dental Age Estimate vs. Long Bone Length Age Estimate (Femur)

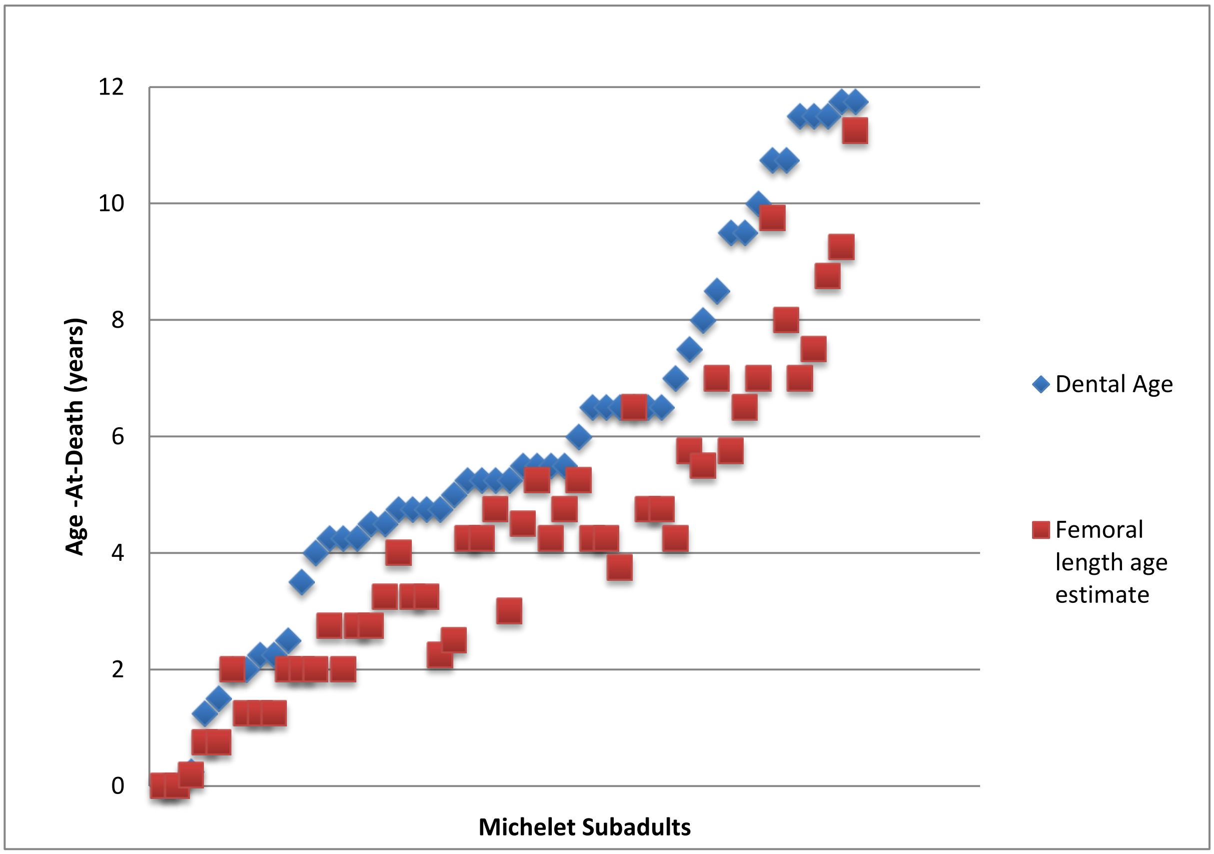


Figure 5.9 – Scatterplot of Dental Age Estimate vs. Long Bone Length Age Estimate (Tibia)

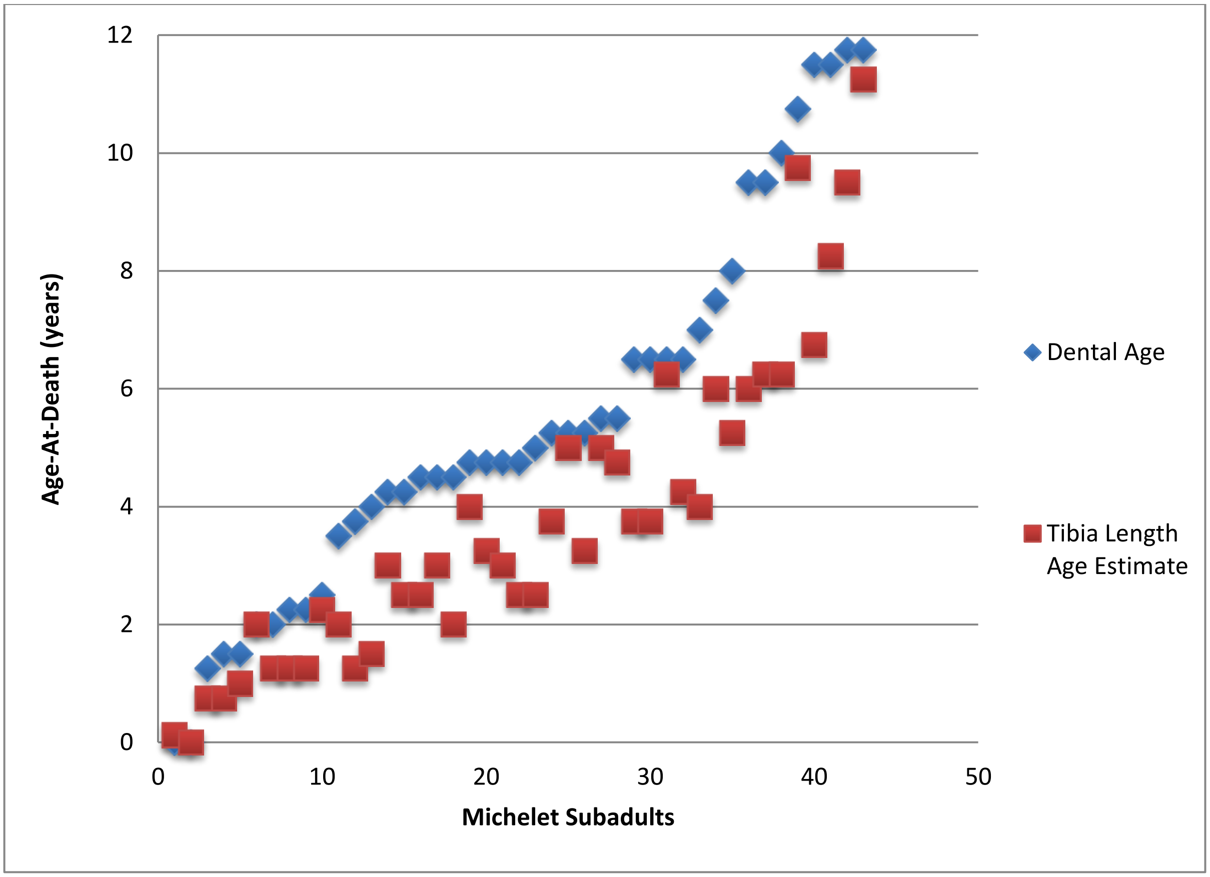


Figure 5.10 – Scatterplot of Dental Age Estimate vs. Long Bone Length Age Estimate (Humerus)

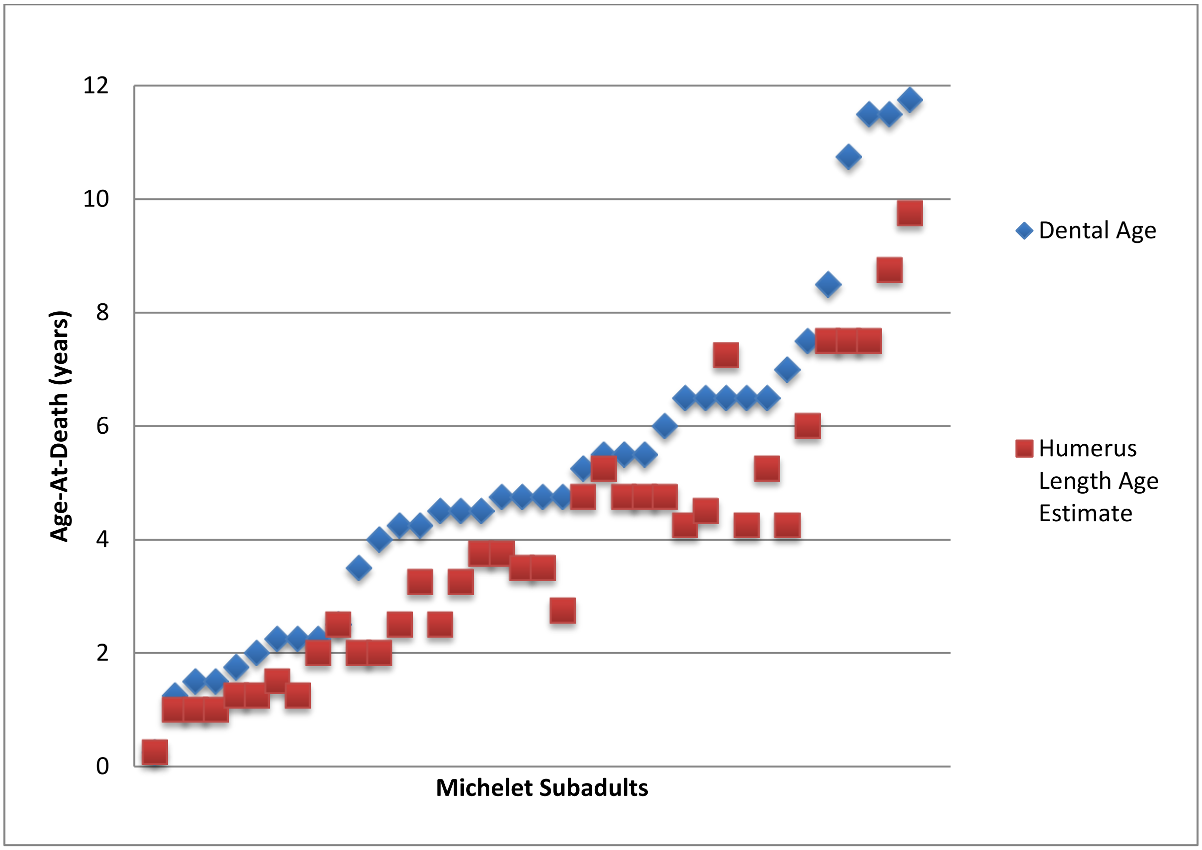


Figure 5.11 – Scatterplot of Dental Age Estimate vs. Long Bone Length Age Estimate (Radius)

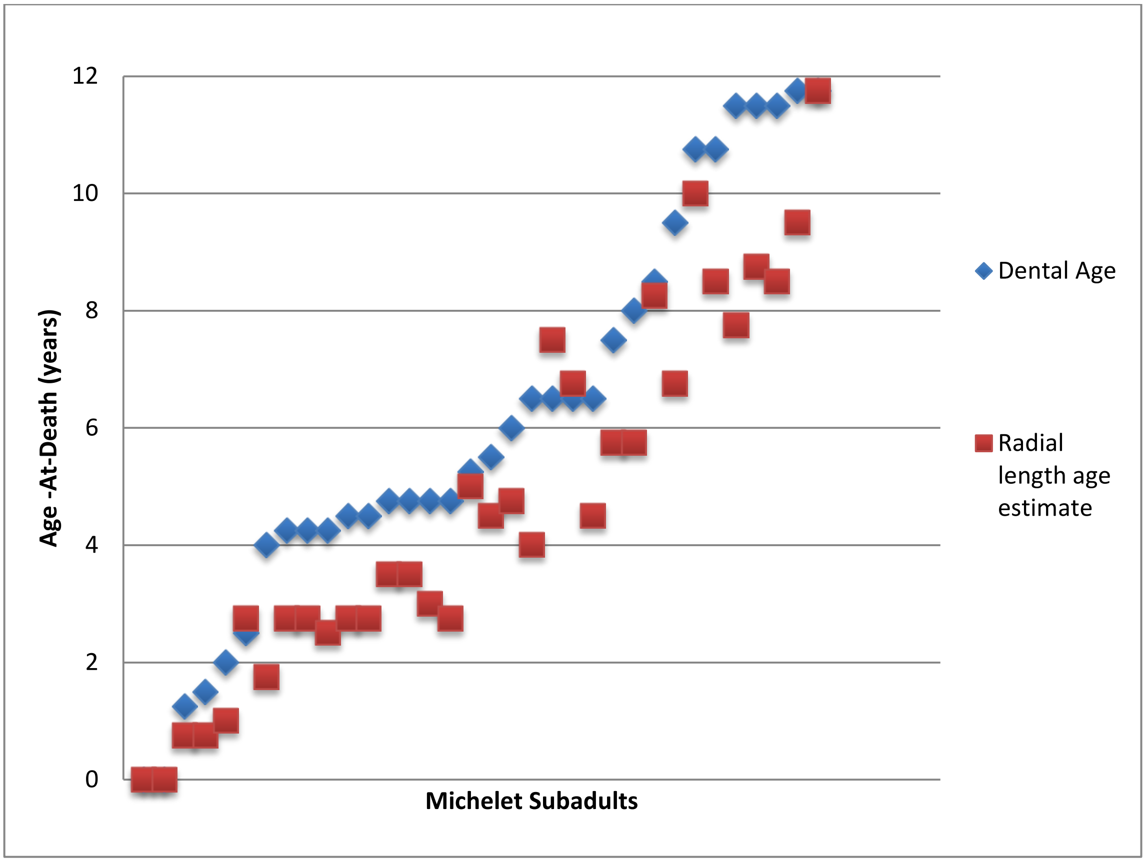


Figure 5.12 – Scatterplot of Dental Age Estimate vs. Long Bone Length Age Estimate (Ulna)

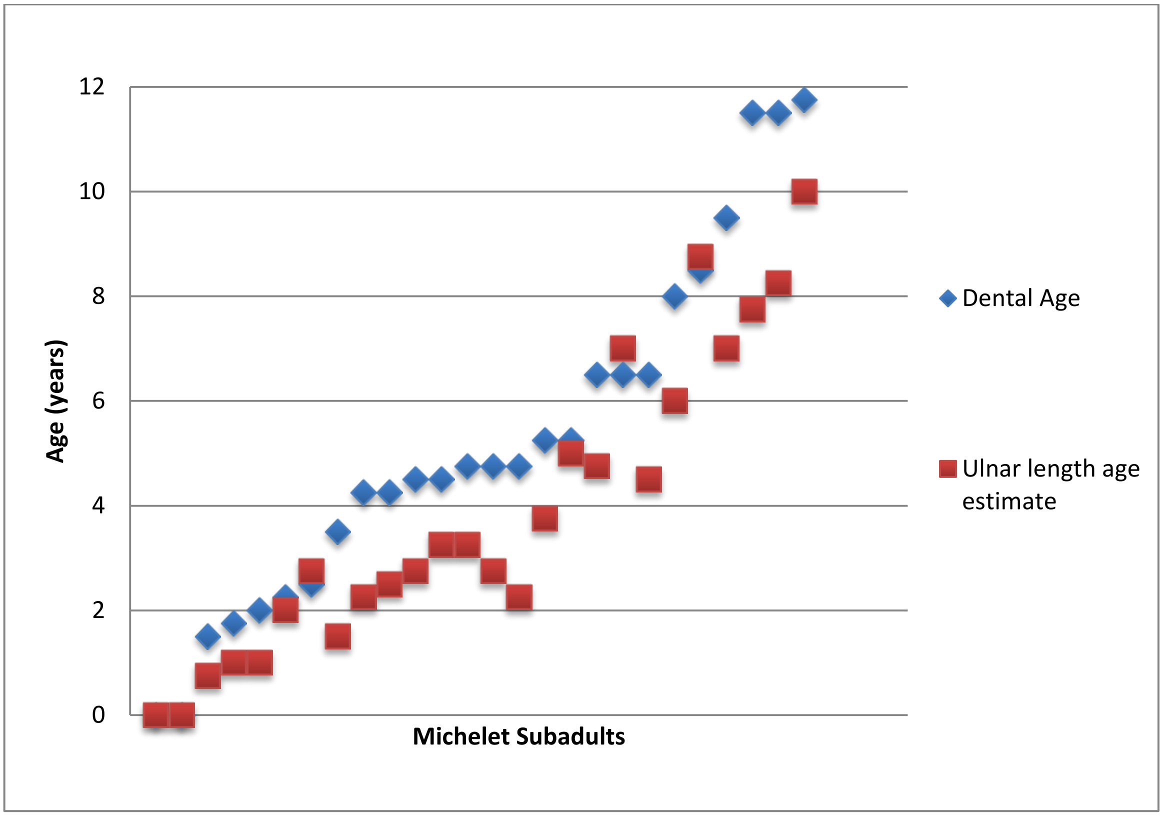


Table 5.8 demonstrates the delay of femoral growth in comparison to dental age in number of years for each individual. Bolded lines indicate separate age categories in the table. For four individuals there was no difference between dental age and skeletal age estimates; three of these belong to the 0-3 year category, and one (MIC 414) belongs to the 6-9 year age category. In general, it appears that older children experienced more skeletal delay than younger individuals. To find if the differences between dental age and long bone length age were significant paired sample t-tests for each long bone were conducted. The data complied with the assumptions of normal distribution independent observation, and homogeneity of variances. Results (Table 5.9) demonstrate that the

difference between the two aging methods is statistically significant for each long bone at the 95% confidence level.

Table 5.8 – Difference Between Dental Age Estimate and Skeletal Age Estimate (Femur)

Individual	Dental Age Estimate (years)	Long bone Length Age Estimate (Femur)	Difference (Long bone length – Dental age)
MIC 7	0	0	0
MIC 251B	0	0	0
MIC 440	0.25	0.19	-0.06
MIC 542	1.25	0.75	-0.50
MIC 123	1.50	0.75	-0.75
MIC 186A	2.00	2.00	0.00
MIC 197	2.00	1.25	-0.75
MIC 253	2.25	1.25	-1.00
MIC 500	2.25	1.25	-1.00
MIC 111	2.50	2.00	-0.50
MIC 853	3.50	2.00	-1.50
MIC 31	4.00	2.00	-2.00
MIC 408	4.25	2.75	-1.50
MIC 423	4.25	2.00	-2.25
MIC 760	4.25	2.75	-1.50
MIC 225	4.50	2.75	-1.75
MIC 256	4.50	3.25	-1.25
MIC 183C	4.75	4.00	-0.75
MIC 347	4.75	3.25	-1.50
MIC 617	4.75	3.25	-1.50
MIC 785	4.75	2.25	-2.50
MIC 18B	5.00	2.50	-2.50
MIC 58	5.25	4.25	-1.00
MIC 275	5.25	4.25	-1.00
MIC 444	5.25	4.75	-0.50
MIC 672	5.25	3.00	-2.25
MIC 205B	5.50	4.50	-1.00
MIC 540	5.50	5.25	-0.25
MIC 773	5.50	4.25	-1.25
MIC 924	5.50	4.75	-0.75
MIC 51	6.00	5.25	-0.75

MIC 91	6.50	4.25	-2.25
MIC 138	6.50	4.25	-2.25
MIC 331	6.50	3.75	-2.75
MIC 414	6.50	6.50	0
MIC 485A	6.50	4.75	-1.75
MIC 622	6.50	4.75	-1.75
MIC 467	7.00	4.25	-2.75
MIC 75	7.50	5.75	-1.75
MIC 435	8.00	5.50	-2.50
MIC 20	8.50	7.00	-1.50
MIC 141	9.50	5.75	-3.75
MIC 245	9.50	6.50	-3.00
MIC 143	10.00	7.00	-3.00
MIC 687	10.75	9.75	-1.00
MIC 769	10.75	8.00	-2.75
MIC 319	11.50	7.00	-4.50
MIC 389	11.50	7.50	-4.00
MIC 616	11.50	8.75	-2.75
MIC 129	11.75	9.25	-2.50
MIC 713	11.75	11.25	-0.50

Table 5.9 – Paired Sample T-tests Difference between Dental Age and Long Bone Length Age Estimates

Dental age – Long bone length	Mean	Standard Deviation	Standard Error Mean	95% Confidence Interval		t	Df	Sig. (2-tailed)
Femur	1.58	1.09	0.15	1.27	1.89	10.36	50	.000
Tibia	1.66	1.16	0.18	1.30	2.02	9.36	42	.000
Humerus	1.22	0.94	0.51	0.91	1.52	8.02	37	.000
Radius	1.40	1.08	0.18	1.04	1.77	7.76	35	.000
Ulna	1.32	1.08	0.20	0.90	1.74	6.49	27	.000

* t, t statistic; df, degrees of freedom; Sig., significant statistic

5.4.2 Comparison to Reference Sample

Z scores are utilized in anthropological studies of growth to indicate the presence of stunting. Z scores in this study were calculated in reference to the Denver sample compiled by Maresh (1970). Z scores are calculated by subtracting long bone length from the Maresh mean long bone length from the same age cohort, and dividing by the standard deviation of the reference sample. For a normal distribution, it is expected that 95% of the scores will lie within 2 standard deviations from the mean. Scores falling below 2 standard deviations are considered evidence of stunting (Cogill 2003). Z scores falling -2 standard deviations below the reference mean are bolded in Table 5.10.

Table 5.10 – Z scores for Long Bone Length

Individual	Dental age (years)	Femur Length	Tibia Length	Humerus Length	Radius Length	Ulna Length
MIC 7	0	-1.58	-0.99	-	-1.26	-
MIC 26	0	**-**	-	-	-1.67	-1.36
MIC 251B	0	**-2.07**	-1.62	-	**-**	**-2.02**
MIC 440	0.25	-0.46	-	-0.14	**-**	-
MIC 542	1.25	-1.17	-1.19	-0.65	-1.44	-
MIC 123	1.50	-0.92	-0.92	-0.44	-0.93	-0.73
MIC 178	1.50	-	-0.74	-0.14	**-**	-
MIC 323	1.75	-	-	0.47	**-**	-0.14
MIC 186A	2.00	-0.13	-0.14	-	**-**	-
MIC 197	2.00	**-2.49**	**-2.07**	-1.91	**-2.14**	**-2.24**
MIC 253	2.25	**-2.58**	**-2.44**	-1.68	**-**	-
MIC 500	2.25	**-2.76**	**-2.25**	**-2.02**	**-**	-
MIC 953	2.25	**-**	**-**	0.23	**-**	-0.24
MIC 111	2.50	-0.30	0.23	0.68	0.90	0.89
MIC 853	3.50	**-2.33**	**-2.56**	-1.45	**-**	**-2.40**
MIC 771	3.75	**-**	**-3.98**	-	-	-
MIC 31	4.00	**-5.09**	**-4.44**	**-3.52**	**-3.49**	-
MIC 408	4.25	**-2.40**	-1.92	-	**-2.06**	**-2.38**

MIC 423	4.25	**-4.41**	-	**-2.57**	**-2.06**	-
MIC 760	4.25	**-2.73**	**-2.67**	-1.41	**-2.18**	**-2.26**
MIC 225	4.50	**-2.65**	**-2.93**	**-2.36**	-1.83	**-2.02**
MIC 256	4.50	-1.72	-1.83	-1.10	-1.59	-1.29
MIC 258	4.50	-	-	-0.46	-	-
MIC 870	4.50	-	**-3.26**	-	-	-
MIC 183C	4.75	-0.04	0.01	-0.15	-0.75	-
MIC 347	4.75	-1.64	-1.83	-0.68	-0.87	-1.17
MIC 617	4.75	-1.64	-1.67	-0.68	-1.35	-1.53
MIC 785	4.75	**-3.74**	**-2.84**	**-2.15**	**-2.06**	**-2.62**
MIC 18B	5.00	**-4.9**	**-4.29**	-	-	-
MIC 58	5.25	-1.73	**-2.21**	-1.18	-	-1.47
MIC 275	5.25	-0.95	-	-	-	-
MIC 444	5.25	-0.70	-0.29	-	0.05	0.17
MIC 672	5.25	**-4.06**	**-2.61**	-	-	-
MIC 205B	5.50	-0.87	-	-	-	-
MIC 540	5.50	0.43	0.11	0.45	-	-
MIC 773	5.50	-1.21	-	-0.37	-0.53	-
MIC 924	5.50	-0.18	-0.61	-0.37	-	-
MIC 51	6.00	-1.22	-	-1.61	-1.51	-
MIC 91	6.50	**-3.38**	**-3.30**	**-2.32**	-	-
MIC 138	6.50	**-3.06**	-	**-2.12**	-	-1.55
MIC 331	6.50	**-3.46**	**-2.78**	-	**-2.31**	-
MIC 414	6.50	1.10	0.23	1.72	1.44	-
MIC 485A	6.50	**-2.42**	-	**-2.01**	-	-
MIC 433	6.50	-	-	-	0.54	1.06
MIC 622	6.50	**-2.10**	**-2.18**	-0.90	-1.96	-1.78
MIC 467	7.00	**-4.52**	**-3.63**	**-3.62**	-	-
MIC 75	7.50	-1.98	-1.42	-0.90	-1.35	-
MIC 435	8.00	**-3.70**	**-3.15**	-	-2.30	**-2.01**
MIC 20	8.50	-1.05	-	-0.26	0.49	0.68
MIC 141	9.50	**-4.43**	**-3.26**	-	-1.97	-1.75
MIC 245	9.50	**-2.98**	-	-	-	-
MIC 493	9.50	-	**-2.81**	-	-	-
MIC 143	10.00	**-3.85**	**-3.53**	-	-	-
MIC 687	10.75	-0.02	-0.13	-	0.08	-
MIC 769	10.75	**-2.43**	-	**-2.39**	-1.39	-
MIC 319	11.50	**-4.64**	**-3.77**	**-3.08**	**-2.77**	**-2.89**
MIC 389	11.50	**-4.17**	-	-1.82	**-2.01**	**-2.16**
MIC 616	11.50	**-2.17**	**-2.16**	-	**-2.30**	-
MIC 129	11.75	-1.70	-1.24	-1.06	-1.35	-0.87
MIC 713	11.75	1.10	.89	-	1.32	-

There are a large number of Michelet individuals with femoral lengths that fall below -2 standard deviations from the reference mean, indicating stunted growth. Though z scores were calculated for the femora, tibiae, humeri, radii, and ulnar lengths, estimates of the total prevalence of stunting (Table 5.11) were calculated using z scores of femoral length. Femoral length is most closely tied to stature which is used to estimate stunting prevalence in anthropological studies, the femur is also expected to be one of the most rapidly growing long bones, and thus may be more sensitive to growth disruption (Mays et al. 2008). A comparison of individuals' z scores across the five long bones shows that when a z score of -2 or below is present in the femur, stunting is also, in most cases, evident in the tibia, humerus, radius and ulna when data are available. It is also clear that for individuals who appear stunted, the magnitude of stunting is greatest in the femora and tibia, and lesser in the humerus, radius and ulna. MIC 31 exhibits the largest degree of stunting with z scores ranging from -3.49 (radius) to as low as -5.09 (femur). Only four individuals had positive z scores for more than two long bones; MIC 111, MIC 540, MIC 414, and MIC 713. None of the positive z scores exceeded 2 standard deviations above the reference mean.

Table 5.11 – Prevalence of Stunting in Michelet Subadults

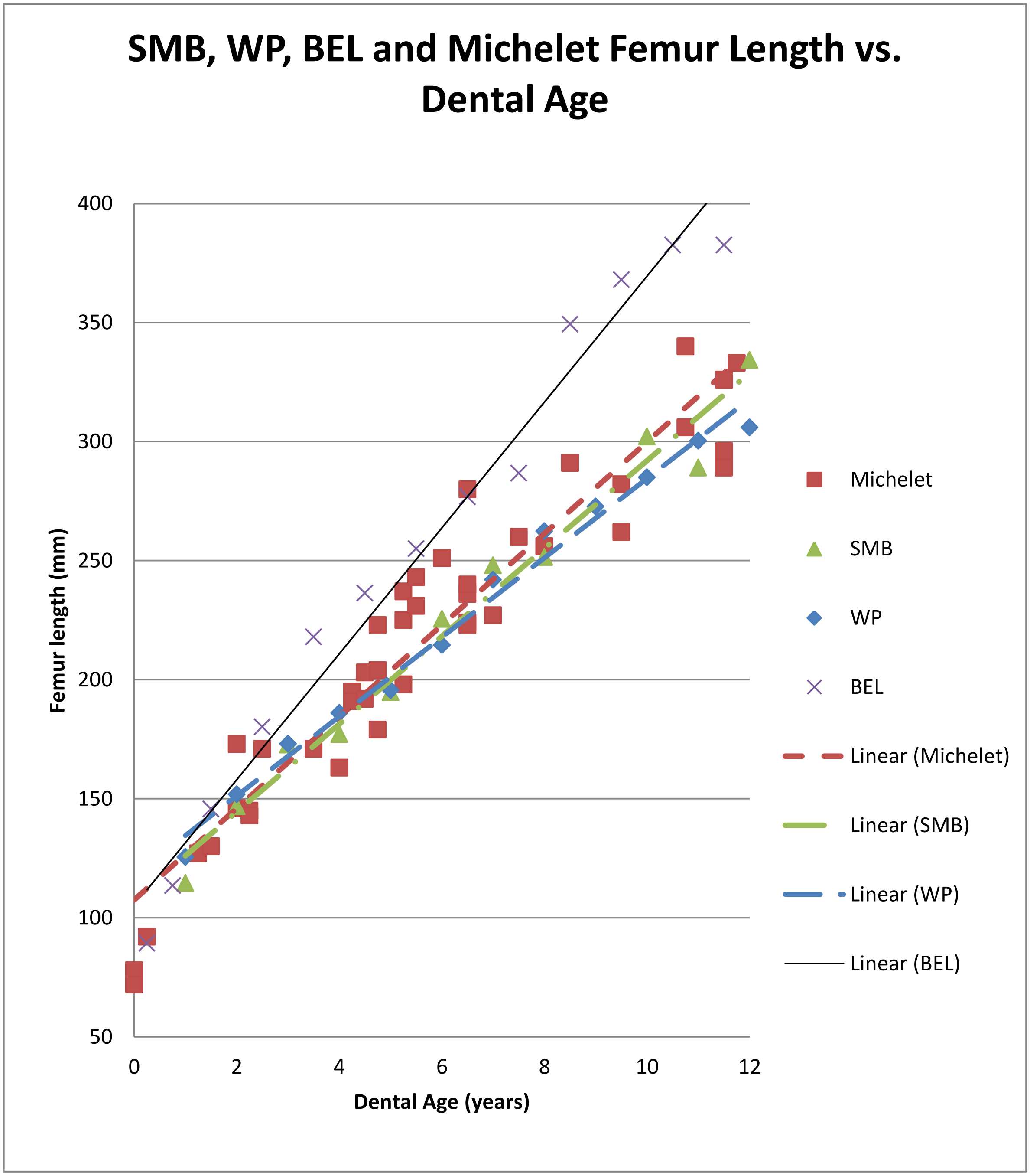
Age Group	Total Number of individuals (Femur)	Number of individuals below -2 SD (Femur)		Number of individuals below -3 SD (Femur)		Number of individuals below -4 SD (Femur)	
0-3 years	10	4	40%	0	-	0	-
3-6 years	21	9	43%	5	24%	4	19%
6-9 years	10	7	70%	5	50%	1	10%
9-12 years	10	7	70%	4	40%	3	30%
Total Prevalence	51	27	53%	14	27%	8	16%

5.4.3 Comparison to Archaeological Samples

Subadult femoral lengths recorded from the Michelet necropolis were plotted against subadult femoral lengths from three other archaeological samples (Fig. 5.13) Skeletal remains from St. Martin's Churchyard, located in Birmingham, England (SMB) date mainly to the first half of the 19th century AD, and represents an urban population from the height of the industrial revolution (Mays et al. 2008). Wharram Percy (WP), located in North Yorkshire, England and represents a rural sample dating to the 10th -19th century AD (Mays et al. 2008). The third sample is from St. Thomas' Church, in Belleville, Ontario (BEL). This sample of known age individuals was from an industrial and manufacturing centre of approximately 7300 residents (Saunders et al. 1993). It should be noted that the femoral length data collected by Mays et al. (2008) for SMB and WP represent maximum femoral lengths for dental ages categories, while the femoral lengths record by Saunders et al. (1993) represent average femoral lengths for individuals of known chronological ages. The Michelet data represent individual femoral lengths.

The Michelet individuals are most similar to SMB and WP samples, while the Belleville sample has demonstrably larger femoral lengths for subadults three years old or greater.

Figure 5.13 Femoral Lengths vs. Dental Age for Four Archaeological Sites



5.5 Appositional Growth and Cortical Thickness Trends

Appositional growth (AP), measured as midshaft width, and cortical thickness (CT) for the femur, tibia, humerus, radius and ulna were plotted against dental age (Figs. 5.14 – 5.18). These scatterplots demonstrate the variability of cortical thickness in relation to dental age. Pearson's correlation coefficient tests were conducted to characterize the relationships between appositional growth and cortical thickness for dental age, as well as cortical thickness against appositional growth (Tables 5.12 – 5.14). The relationship for appositional growth for each long bone and dental age was strong and positive at the 95% confidence level. Pearson's correlation coefficient tests between AP and CT were also strong and positive at the 95% confidence interval. Pearson's correlation coefficient tests for cortical thickness and dental age, however, revealed weaker relationships that were characterized as moderate ($R<.700$) or strong ($R> .700$), positive, and significant at the 95% confidence level.

Figure 5.14- Scatterplot of Appositional Growth (Femur) vs. Dental Age

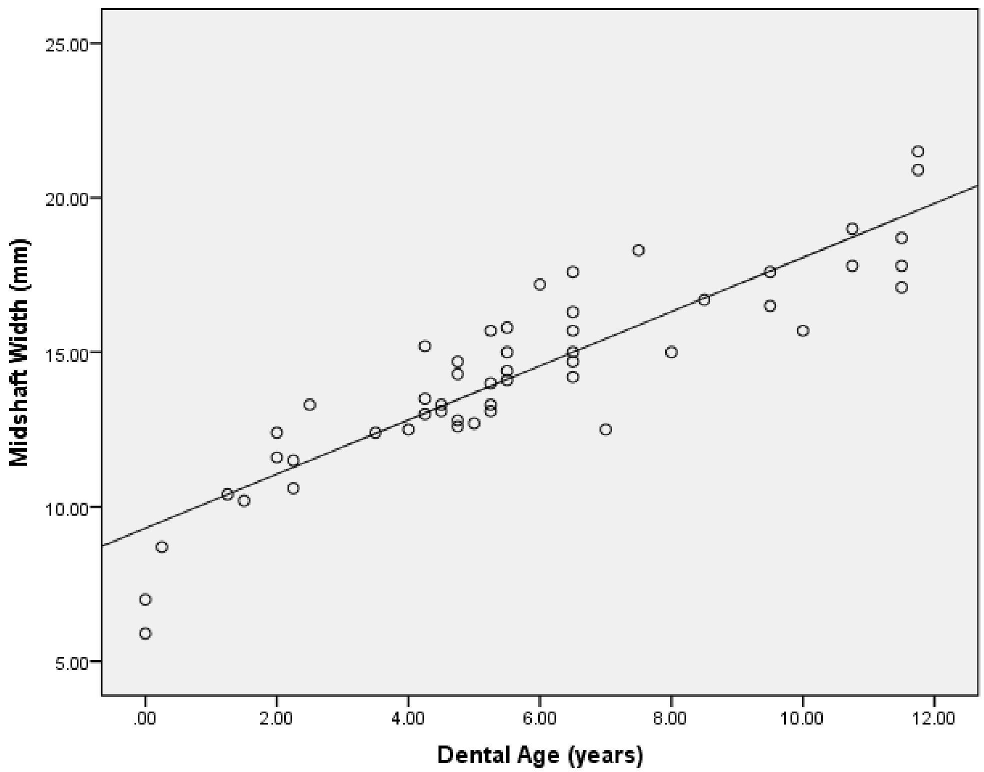


Figure 5.15 – Scatterplot of Appositional Growth (Tibia) vs. Dental Age

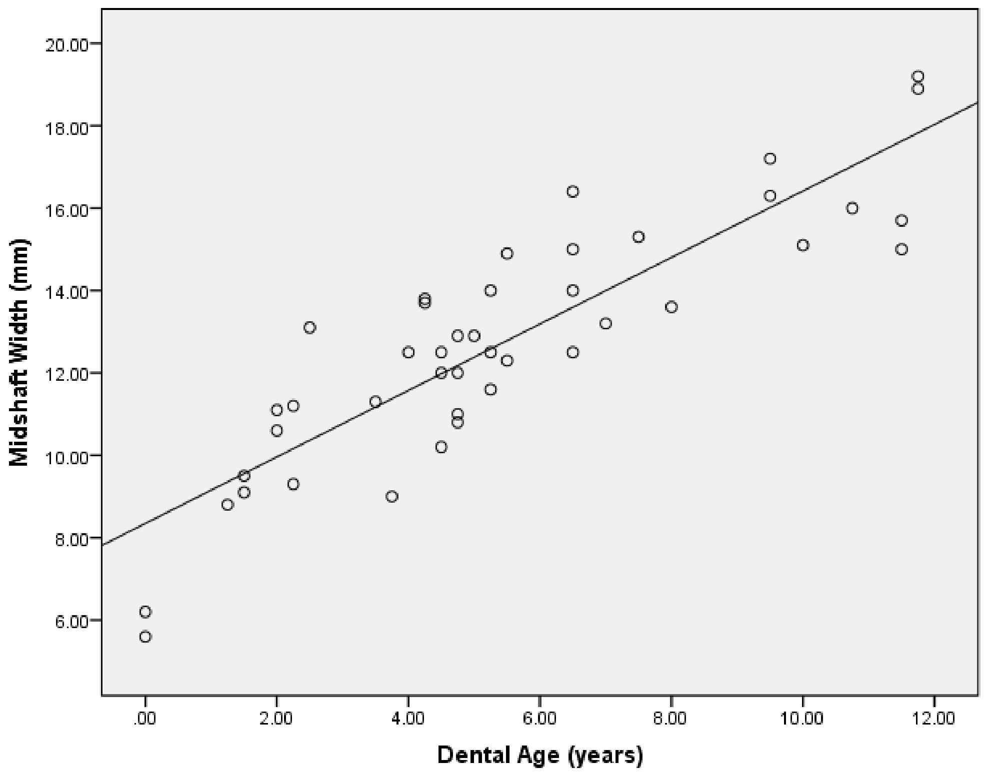


Figure 5.16 – Scatterplot of Appositional Growth (Humerus) vs. Dental Age

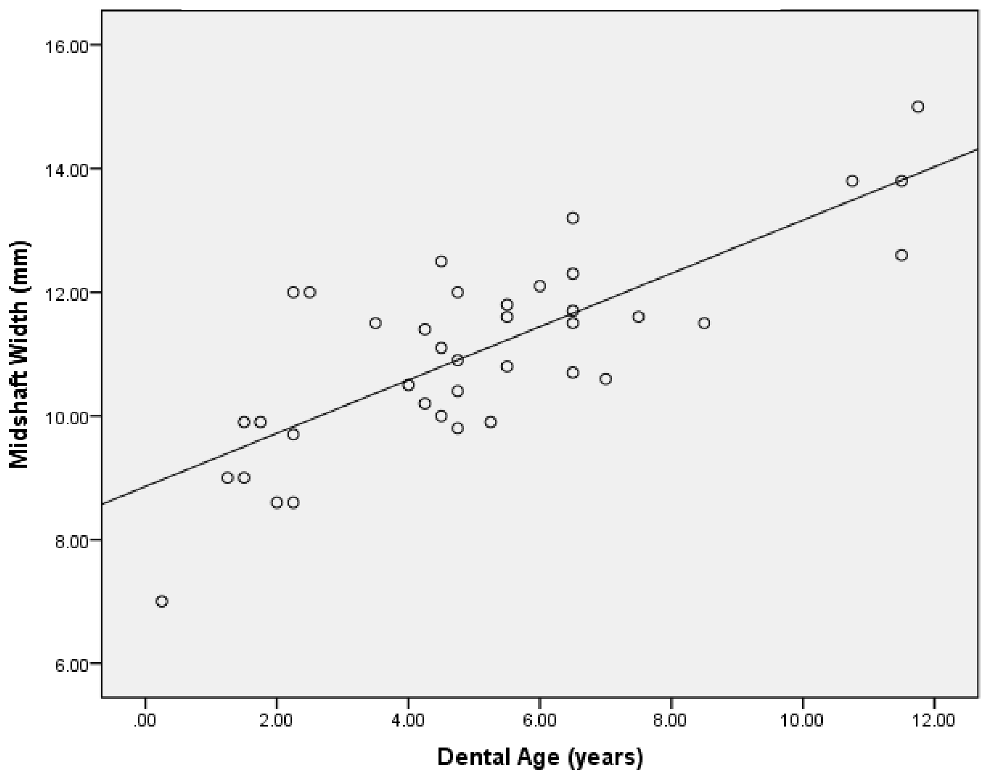


Figure 5.17 – Scatterplot of Appositional Growth (Radius) vs. Dental Age

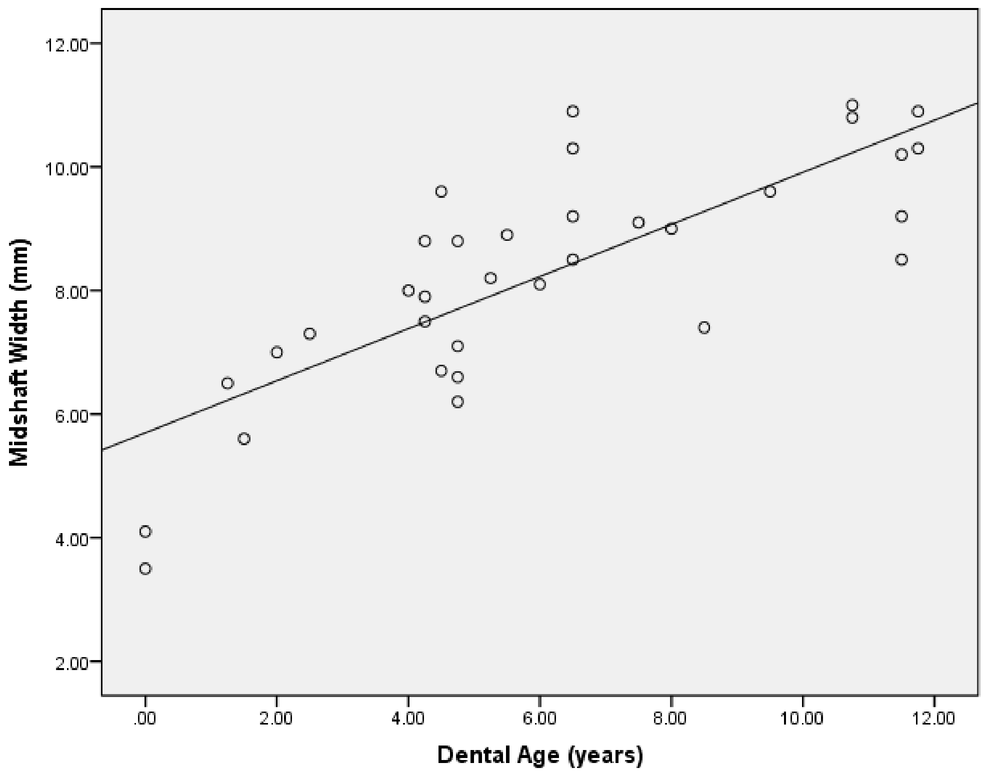


Figure 5.18 – Scatterplot of Appositional Growth (Ulna) vs. Dental Age

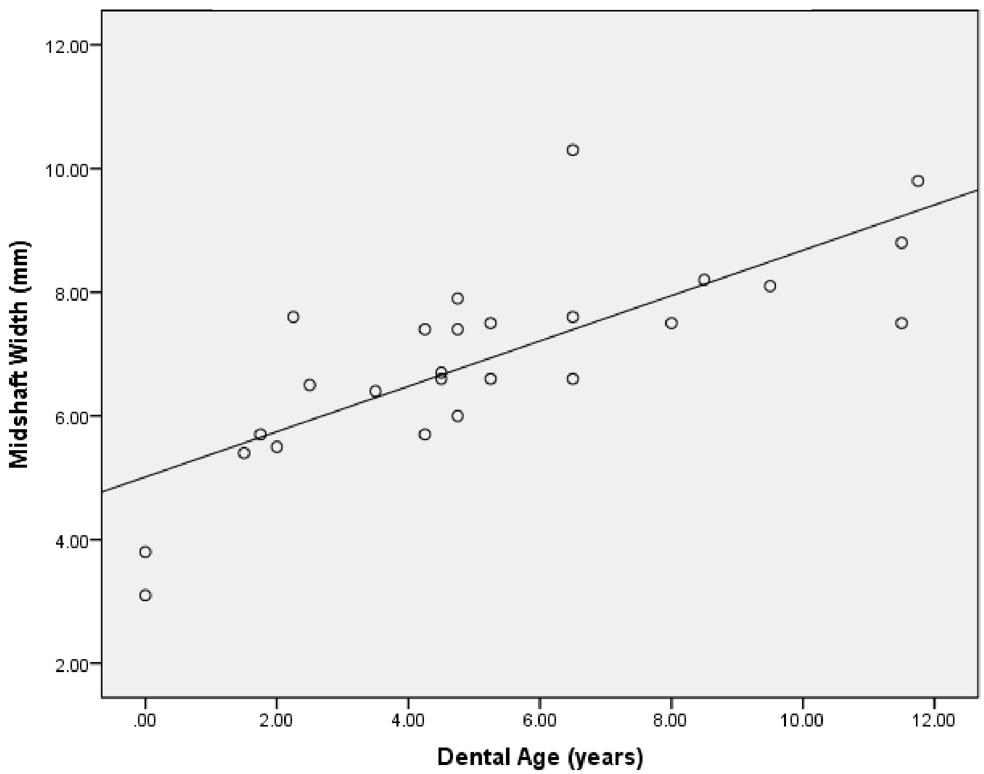


Figure 5.19 – Scatterplot of Cortical Thickness (Femur) vs. Dental Age

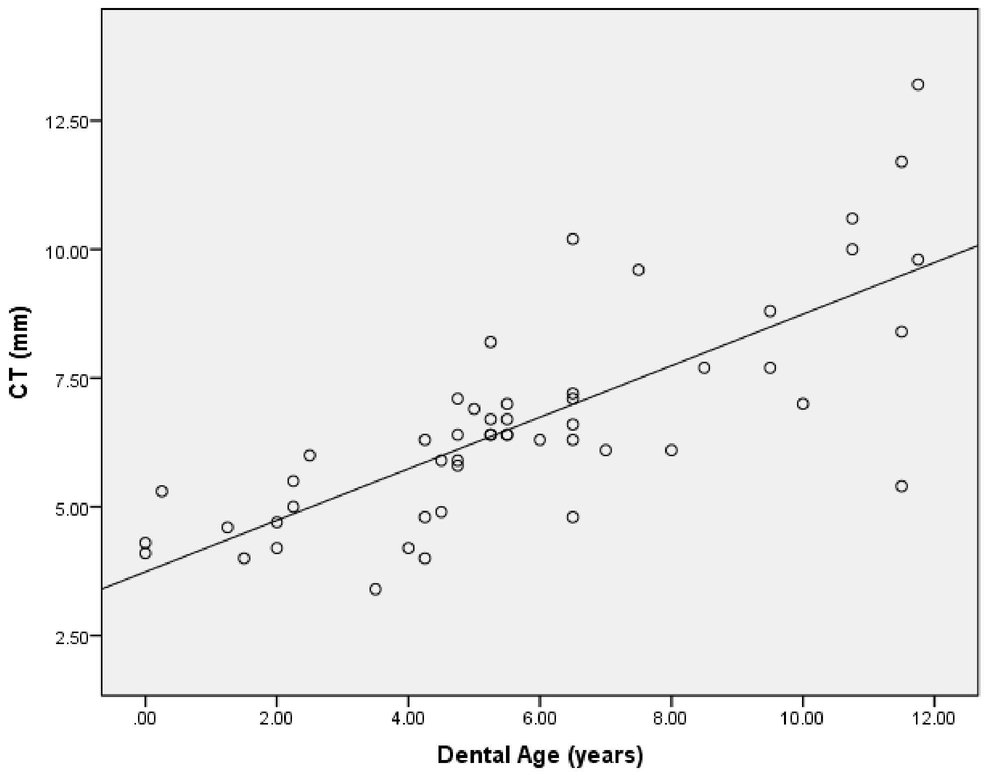


Figure 5.20 – Scatterplot of Cortical Thickness (Tibia) vs. Dental Age

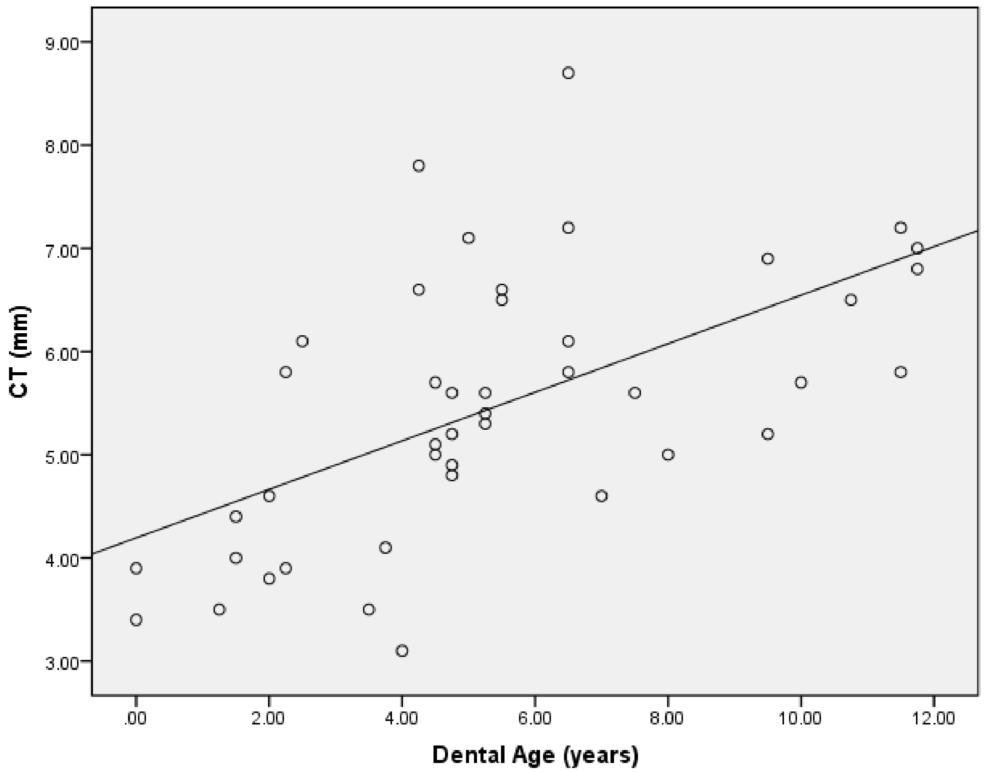


Figure 5.21 – Scatterplot of Cortical Thickness (Humerus) vs. Dental Age

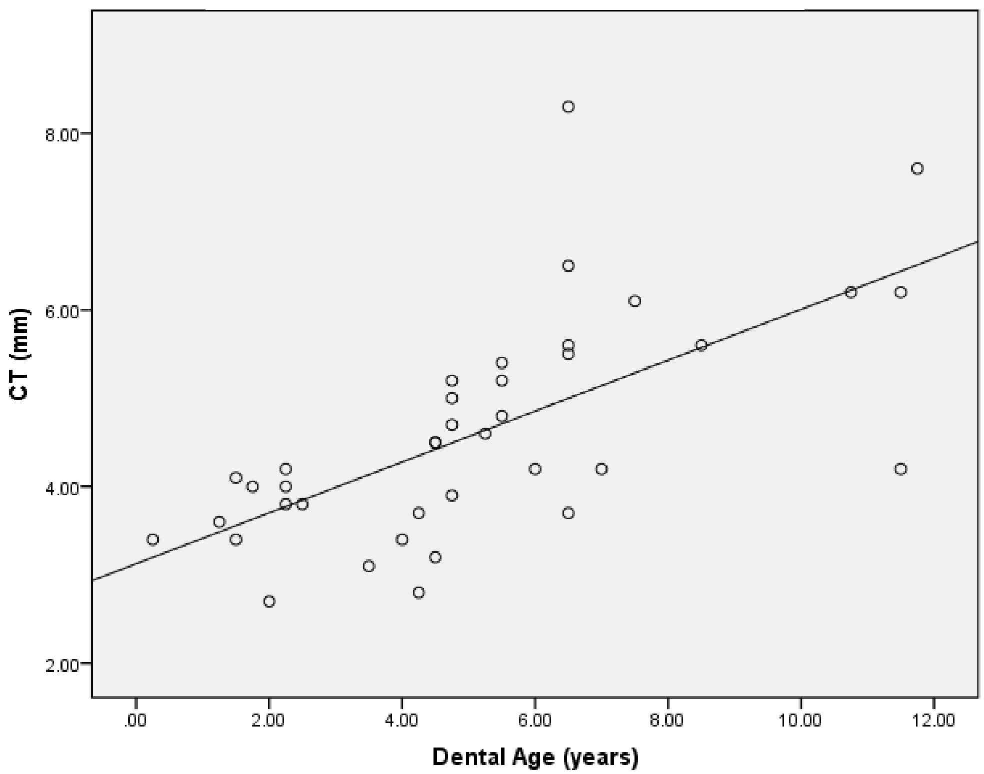


Figure 5.22 – Scatterplot of Cortical Thickness (Radius) vs. Dental Age

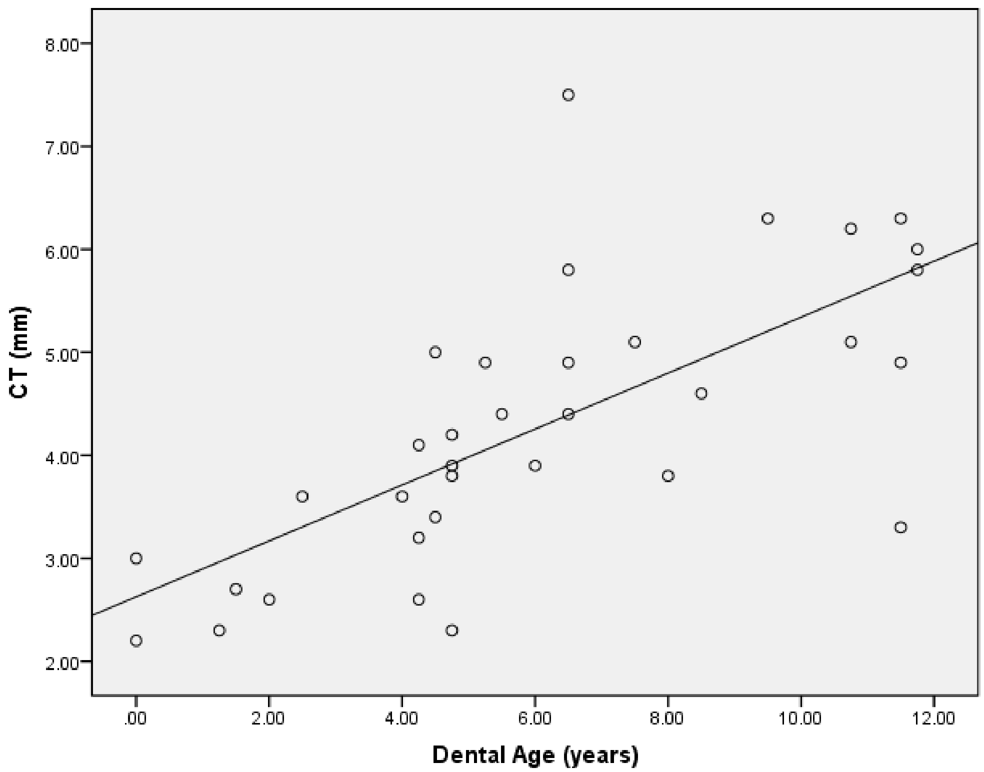


Figure 5.23 – Scatterplot of Cortical Thickness (Ulna) vs. Dental Age

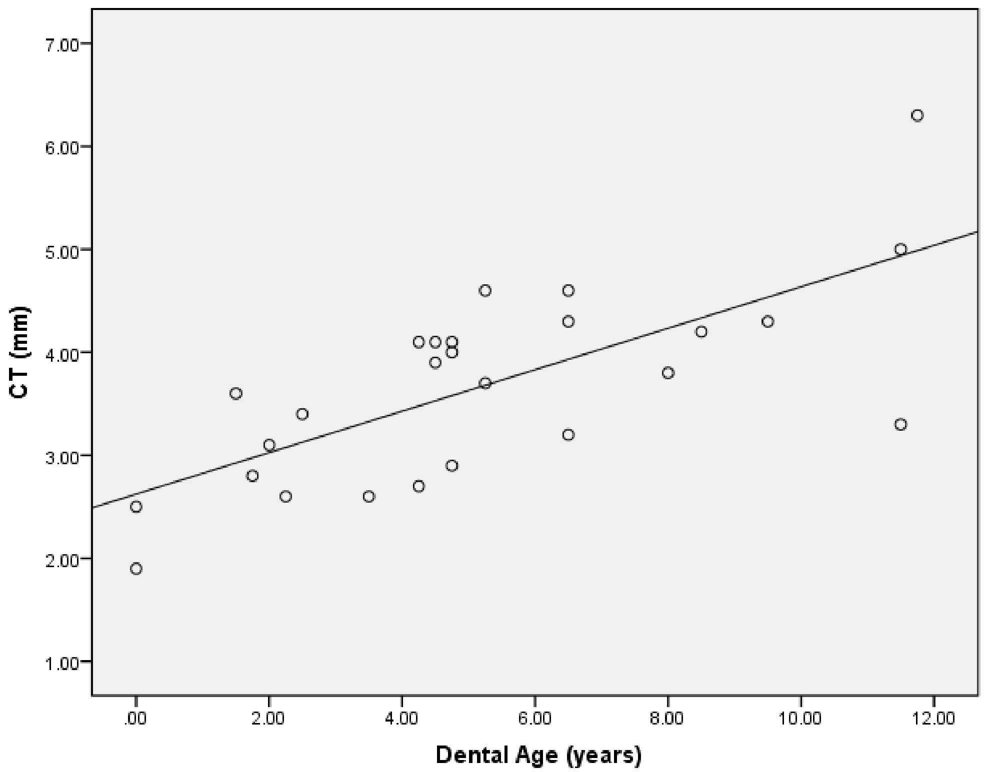


Table 5.12 – Pearson's Correlation Coefficient Tests – Dental Age vs. Appositional Growth

	Femur AP vs. Dental Age	Tibia AP vs. Dental Age	Humerus AP vs. Dental Age	Radius AP vs. Dental Age	Ulna AP vs. Dental Age
R	0.90	0.88	0.78	0.79	0.77

* R, Pearson's Correlation Coefficient

Table 5.13 – Pearson's Correlation Coefficient Tests – Dental Age. Vs. Cortical Thickness

	Femur CT vs. Dental Age	Tibia CT vs. Dental Age	Humerus CT vs. Dental Age	Radius CT vs. Dental Age	Ulna CT vs. Dental Age
R	0.77	0.58	0.66	0.70	0.71

* R, Pearson's Correlation Coefficient

Table 5.14 – Pearson's Correlation Coefficient Test Appositional Growth vs. Cortical Thickness

	Femur CT/AP	Tibia CT/AP	Humerus CT/AP	Radius CT/AP	Ulna CT/AP
R	0.80	0.72	0.70	0.78	0.82

* R, Pearson's Correlation Coefficient

A hierarchical multiple regression analysis was conducted to see if appositional growth or cortical thickness varied for individuals buried with or without grave goods, those buried in different grave types, or those who lived during the late Roman or Merovingian period (Table 5.15). The data met requirements of normality, linearity, multicollinearity, singularity, outliers, and homoscedasticity. The analysis demonstrated no significant differences when date, burial, presence/absence of grave goods, or grave type were added as predictor variables for appositional growth or cortical thickness.

Table 5.15 Hierarchical Multiple Regression Sig. F Change Values – Appositional Growth and Burial Date

	Femur AP Dental Age	Tibia AP vs. Dental Age	Humerus AP vs. Dental Age	Radius AP vs. Dental Age	Ulna AP vs. Dental Age
R^2 Change	0.00	0.00	0.01	0.02	0.06
Significant F Change	0.35	0.79	0.25	0.20	0.07

Table 5.16 Hierarchical Multiple Regression Sig. F Change Values – Appositional Growth and Grave Good Presence/Absence

	Femur AP Dental Age	Tibia AP vs. Dental Age	Humerus AP vs. Dental Age	Radius AP vs. Dental Age	Ulna AP vs. Dental Age
R^2 Change	0.00	0.01	0.00	0.00	0.00
Significant F Change	0.88	0.21	0.67	0.81	0.77

Table 5.17 Hierarchical Multiple Regression Sig. F Change Values – Appositional Growth and Burial Type

	Femur AP vs. Dental Age	Tibia AP vs. Dental Age	Humerus AP vs. Dental Age	Radius AP vs. Dental Age	Ulna AP vs. Dental Age
R^2 Change	0.00	0.01	0.00	0.00	0.01
Significant F Change	0.59	0.12	0.84	0.55	0.53

Table 5.18 - Hierarchical Multiple Regression Sig. F Change Values – Cortical Thickness and Date

	Femur CT vs. Dental Age	Tibia CT. vs. Dental Age	Humerus CT vs. Dental Age	Radius CT vs. Dental Age	Ulna CT vs. Dental Age
R^2 Change	0.00	0.00	0.00	0.00	0.01
Significant F Change	0.69	0.96	0.76	0.89	0.62

Table 5.19 - Hierarchical Multiple Regression Sig. F Change Values – Cortical Thickness and Grave Good Presence/Absence

	Femur CT vs. Dental Age	Tibia CT vs. Dental Age	Humerus CT vs. Dental Age	Radius CT vs. Dental Age	Ulna CT vs. Dental Age
R^2 Change	0.01	0.01	0.00	0.01	0.00
Significant F Change	0.29	0.49	0.78	0.39	0.94

Table 5.20 - Hierarchical Multiple Regression Sig. F Change Values – Cortical Thickness and Burial Type

	Femur CT vs. Dental Age	Tibia CT vs. Dental Age	Humerus CT vs. Dental Age	Radius CT vs. Dental Age	Ulna CT vs. Dental Age
R^2 Change	0.01	0.03	0.01	0.00	0.00
Significant F Change	0.27	0.22	0.36	0.73	0.68

Hierarchical multiple regression analyses compared potential differences in growth slopes and found no significant differences. Further, differences in the standardized residuals of dental age and CT between dates, presence/absence of grave goods, and burial types were tested, and no significant differences were found.

Standardized residuals are similar to z scores in that they demonstrate, in standardized units, how far a single measurement is above or below the expected value. Assumptions regarding normality were met. T-tests were then conducted to determine if the distribution of standardized residuals of CT differed significantly between late Roman and Merovingian burials, absence/presence of grave goods, and burial type (Tables 5.21-5.27).

Table 5.21 – T-test of Femoral Cortical Thickness Standardized Residuals Between Late Roman and Merovingian Subadults

	Roman		Merovingian			
	Mean	SD	Mean	SD	*T*	*P*
Femur CT	0.04	1.11	-0.08	0.67	.40	0.69
Tibia CT	0.00	1.10	0.02	0.48	-0.06	0.96
Humerus CT	0.03	1.11	-0.07	0.69	0.31	0.76
Radius CT	-0.01	1.07	0.05	0.62	-0.14	0.89
Ulna CT	0.06	1.07	-0.16	0.74	0.50	0.62

*T, T statistic; P, significance value

Table 5.22– T-test of Femoral Cortical Thickness Standardized Residuals Between Absence/Presence of Grave Goods

	No Grave Goods		Grave Goods Present			
	Mean	SD	Mean	SD	*T*	*P*
Femur CT	0.04	1.01	-0.51	0.65	1.07	0.28
Tibia CT	-0.39	0.91	0.29	1.56	-0.70	0.49
Humerus CT	0.01	1.02	-0.15	0.53	0.28	0.79
Radius CT	0.05	1.02	-0.41	0.57	0.88	0.39
Ulna CT	0.01	1.01	-0.03	0.96	0.07	0.94

*T, T statistic; P, significance value

Table 5.23 – ANOVA of Standardized Residuals Between Grave Types (Femur)

Femoral CT	N	Mean	SD	*P*
(0) Earth Cut	10	-0.32	0.68	Beween Groups: 0.69
(1) Wooden Coffin	31	0.03	1.07	
(2) Wedging Stone burials	8	0.22	0.39	

*P, significance value

Table 5.24 – ANOVA of Standardized Residuals Between Grave Types (Tibia)

Tibia CT	N	Mean	SD	*P*
(0) Earth Cut	6	-0.40	0.77	Between Groups: 0.30
(1) Wooden Coffin	27	0.04	1.05	
(2) Wedging Stone burials	9	-0.04	0.86	

*P, significance value

Table 5.25 – ANOVA of Standardized Residuals Between Grave Types (Humerus)

Humerus CT	N	Mean	SD	*P*
(0) Earth Cut	7	-0.28	0.72	Between Groups: 0.82
(1) Wooden Coffin	24	0.02	1.12	
(2) Wedging Stone burials	6	0.20	0.81	

*P, significance value

Table 5.26 – ANOVA of Standardized Residuals Between Grave Types (Radius)

Radius CT	N	Mean	SD	*P*
(0) Earth Cut	6	0.03	0.40	Between Groups: 0.89
(1) Wooden Coffin	24	0.03	1.14	
(2) Wedging Stone burials	4	-0.24	0.62	

*P, significance value

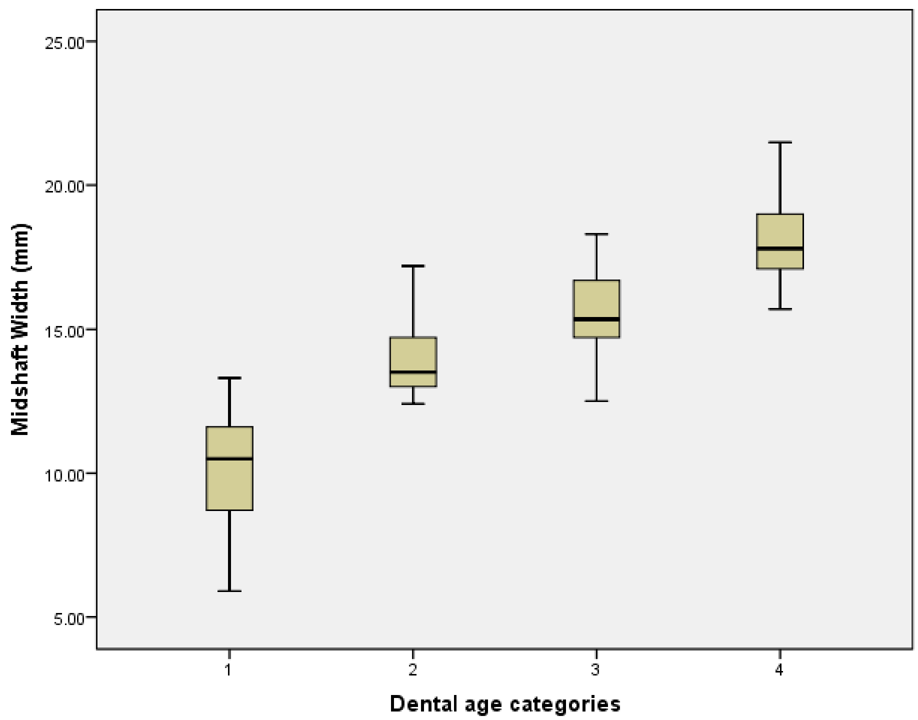
Table 5.27 – ANOVA of Standardized Residuals Between Grave Types (Ulna)

Ulna CT	N	Mean	SD	*P*
(0) Earth Cut	4	-0.04	1.20	Between Groups: 0.71
(1) Wooden Coffin	16	-0.12	0.93	
(2) Wedging Stone burials	5	0.47	1.14	

*P, significance value

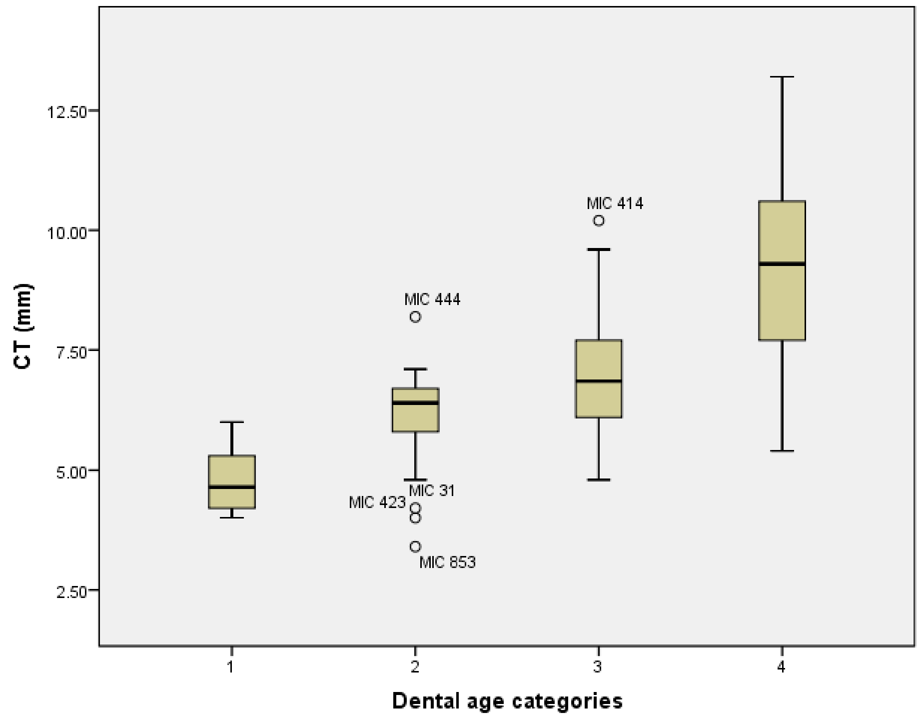
Box plots for Femoral AP and CT were created to identify outliers. No outliers were found for femoral AP, but there were a total of 5 outliers for femoral CT (Figs. 5.24 – 5.25). MIC 31, MIC 423, and MIC 853 all belonging to the 3-6 year age category and fall below the average distribution of CT for that age group. Two individulas had very high CT; MIC 444 and MIC 414. MIC 444 belongs to the 3-6 year age group and MIC 414 belongs to the 6-9 year age group. The three individuals with low CT for age also had stunted long bone growth. The two individuals with high CT for age were not stunted.

Figure 5.24 – Boxplot of Femur AP For Age



*** 1) 0-3 years 2) 3-6 years 3) 6-9 years 4) 9-12 years*

Figure 5.25 – Boxplot of Femur CT For Age



*** 1) 0-3 years 2) 3-6 years 3) 6-9 years 4) 9-12 years*

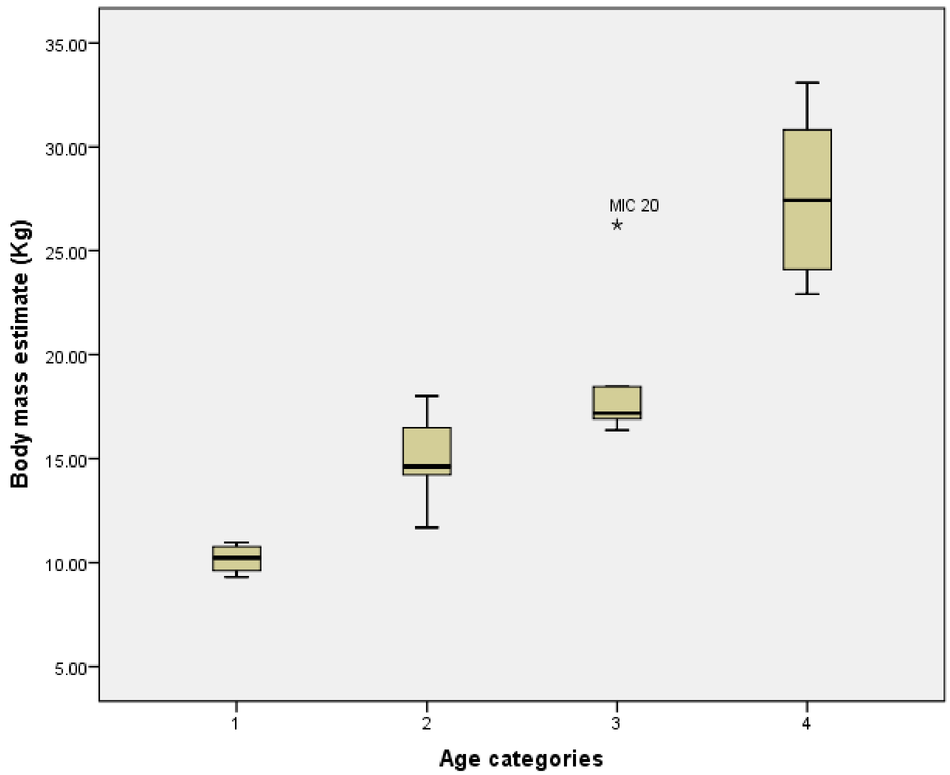
5.6 Body Mass Estimation

Body mass estimations for individuals 1-12 years old were calculated when the necessary measurement was available. Of a total sample of 60 individuals, body mass was estimated for 32 individuals. Table 5.28 presents the descriptive statistics of the body mass estimates. Body mass estimates were plotted against dental age in a scatterplot (Figure 5.26) and a correlation test was conducted to characterize how closely body mass estimates were related to age. Pearson's correlation coefficient tests demonstrated a strong positive relationship significant at the 95% confidence interval. MIC 20 was identified as having a much larger estimated body mass in relation to dental age. MIC 20 is thought to date to the Merovingian period and was buried in wooden coffin with no grave goods. This individual is aged 8.5 years old and represents the older half of the age category (6-9 year olds). The body mass estimate for MIC 20 is within the 9-12 year old range of body mass estimates.

Table 5.28 – Minimum, Maximum and Average Body Mass Estimates by Age Category

Age (years)	N	Min (Kg)	Max (Kg)	Mean (Kg)	Standard deviation
(0-3)	4	9.30	11.00	10.19	0.73
(3-6)	13	11.70	18.00	15.19	1.94
(6-9)	5	16.40	26.30	19.04	4.11
(9-12)	10	22.90	33.10	27.64	3.60

Figure 5.26 Box Plot of Body Mass Estimations by Age Group



*** 1) 0-3 years 2) 3-6 years 3) 6-9 years 4) 9-12 years*

Additional hierarchical multiple regression tests were conducted to see if body mass estimates varied significantly between individuals buried in different grave types, those buried with or without grave goods, and between the late Roman and Merovingian periods at Michelet. Results demonstrated that the presence/absence of grave goods, the addition of date or grave type as an independent variable, or date made no significant contribution to the relationship between dental age and body mass estimates (Table 5.29).

Table 5.29 – Hierarchical Multiple Regression Analysis of Body Mass

	Date	Grave Goods	Grave Type
R Change	0.00	0.00	0.00
Significant F Change	0.86	0.57	0.86

Body mass for age was compared against available weight for age data for boys and girls 0-5 years of age collected by the WHO (2006). Median values of weight for age for boys and girls were averaged and plotted against the Michelet body mass estimates for age (Fig. 5.27). The scatterplot demonstrates that the subadults from Michelet have consistently lower body mass estimates than the median WHO healthy values. An independent t-test, however, demonstrated that this difference is not significant at the 95% confidence interval (Table 5.30). Additional t-tests were conducted to compare means between body mass estimates from the late Roman and Merovingian context and between individuals with and without grave goods (Tables 5.31, 5.32). A significant difference in body mass estimates was found between individuals with and without grave goods. The sample size was quite small for individuals with grave goods (N=4) and the test violated the assumption of equal variances. T and P values for the assumption of unequal variances were considered and recorded instead. However, this result is not considered robust as all the individuals with grave goods and body mass estimates were under 4.5 years of age and likely skewed these results. An ANOVA test was conducted to compare means of body mass estimates between grave types which returned no significant results (Table 5.33).

Figure 5.27 – Scatterplot of Body Mass Estimations Between WHO Standard and Michelet Subadults

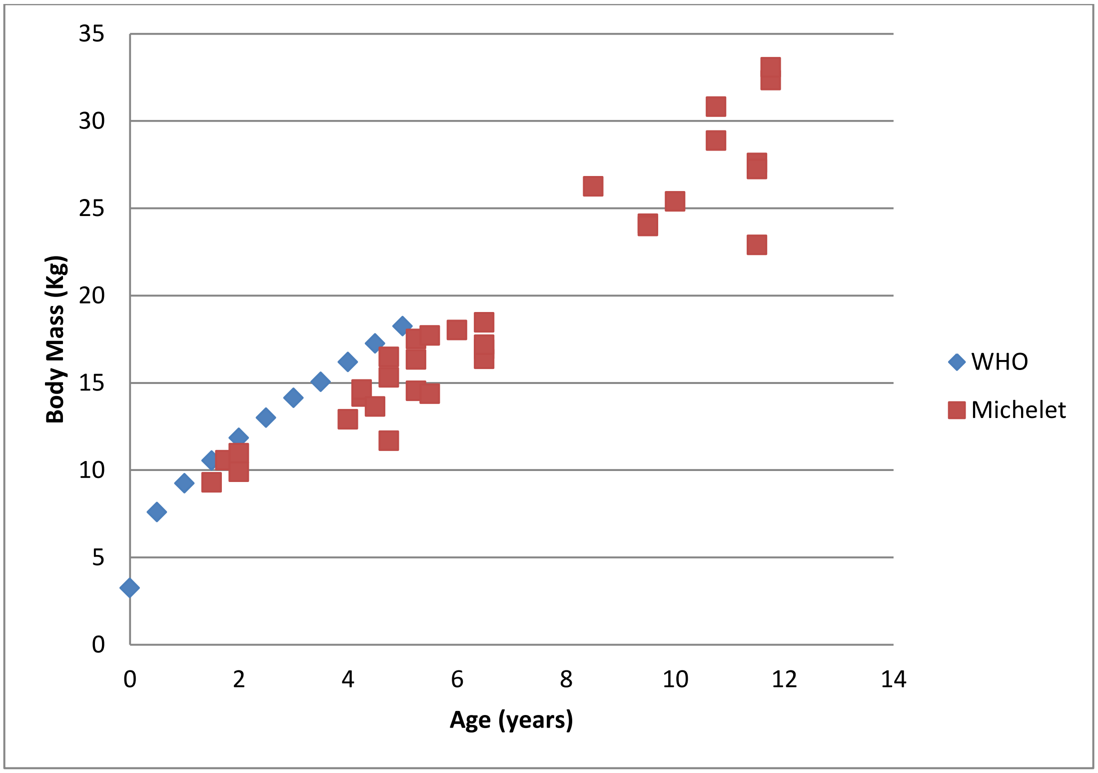


Table 5.30 – T-test of Standardized Residuals Between WHO Standard and Michelet Body Mass Estimates

	WHO		Michelet			
	Mean	SD	Mean	SD	*T*	*P*
Body Mass	12.40	4.51	12.72	2.36	-0.21	0.84

*T, T statistic; P, significance value

Table 5.31 – T-test of Body Mass Estimates Between Late Roman and Merovingian Subadults

	Roman		Merovingian			
	Mean	SD	Mean	SD	*T*	*P*
Body Mass	19.38	7.49	18.08	5.02	0.46	0.65

*T, T statistic; P, significance value

Table 5.32 – T-test of Body Mass Estimates Between Subadults With and Without Grave Goods

	No Grave Goods		Grave Goods			
	Mean	SD	Mean	SD	*T*	*P*
Body Mass	20.04	6.77	12.18	2.64	4.27	.002

*T, T statistic; P, significance value
**N=4 sample size for individuals with grave goods. Levene's test for equality of variance was significant, P and T values based off of values calculated when equal variances are not assumed.

Table 5.33 – ANOVA of Body Mass Estimates Between Grave Types

	Body Mass			
Grave Type	N	Mean	SD	*P*
Earth Cut	7	18.07	7.24	Between groups: 0.61
Wooden Coffin	20	19.83	6.51	
Wedging Stone and Wooden Component	4	19.00	9.41	
Sarcophagus	1	10.57	N/A	

*P, significance value

5.7 Rickets at Michelet

There are a number of subadults who exhibited macroscopic and radiographic features characteristic of rickets (12/130); approximately 9% of all individuals analysed. 6.1% of individuals (8/130) had active cases and 2.3% of individuals (3/130) had a healed case (one individual had insufficient skeletal elements preserved to determine the state of vitamin D deficiency). Pathology recording forms for rachitic individuals filled out during field recording for the SSHRC funded project 'Social-Cultural Determinants of Community Wellbeing in the Western Roman Empire: Analysis and Interpretation of Vitamin D Status' are in Appendix B. MIC 144 only had two teeth available for aging, no complete long bones and was subsequently not included in the previous growth analyses. Similarly, MIC 234 had no teeth available for analysis and was not included in the previous growth analysis. Table 5.34 displays contextual information regarding age, whether the pathological changes are considered healed or active, burial type, and grave good presence/absence. The blue shaded area contains information regarding the rachitic late Roman individuals, and the grey shaded area contains contextual information regarding individuals buried the Merovingian period. A chi square test determined that there was no statistically significant difference between the number of cases of rickets from the late Roman and Merovingian period. There is also no pattern in terms of individuals affected in different grave types. Figure 5.28 and 5.29 illustrate the distributions of rachitic individuals during the late Roman and Merovingian time periods grouped by age category. The two figures also demonstrate the proportion of individuals within the sample that had macroscopic and radiologic evidence of rickets in comparison to the number of individuals in the sample with either no, or insufficient evidence of rickets. The two oldest individuals that exhibited pathological changes indicative of rickets had healed cases indicating that they were deficient at a younger age, and had since recovered. The majority of subadults who had active cases of rickets were younger, ranging from a few months old up until 5 or 6 years old.

Table 5.34 – Rachitic Individuals and Contextual Data

Individual	Age	Diagnosis	Healed / Active	Grave Type	Grave Good	Date
MIC 31	3-5 years	Possible	Active	Earth Cut	None	4^{th} – 5^{th} c.
MIC 95	6 mos	Probable	Active	Earth Cut	None	4^{th} – 5^{th} c.
MIC 141	9-10 years	Possible	Healed	Wooden Coffin	None	4^{th} – 5^{th} c.
MIC 144	7-18 mos	Possible	Insufficient Evidence	Wooden Coffin	Grave goods	4^{th} – 5^{th} c.
MIC 347	4-5.5 years	Possible	Active	Wooden Coffin	Grave goods	4^{th} – 5^{th} c.
MIC 440	2-4 mos	Probable	Active	Wooden Coffin	None	4^{th} – 5^{th} c.
MIC 542	1 – 1.5 years	Probable	Active	Wooden Coffin	None	4^{th} – 5^{th} c.
MIC 713	11.5-12 years	Possible	Healed	Wooden Coffin	None	4^{th} – 5^{th} c.
MIC 54	5-6 years	Possible	Active	Earth Cut	None	7^{th} – 8^{th} c.
MIC 234	3-4 years	Probable	Active	Earth Cut	None	7^{th} – 8^{th} c.
MIC 500	2-2.5 years	Possible	Healed	Wedging Stones and Nails	None	7^{th} – 8^{th} c.
MIC 277	3-5 mos	Probable	Active	Wedging Stone	None	7^{th} – 8^{th} c.

Figure 5.28– Frequency of Rickets in the late Roman Michelet Sample

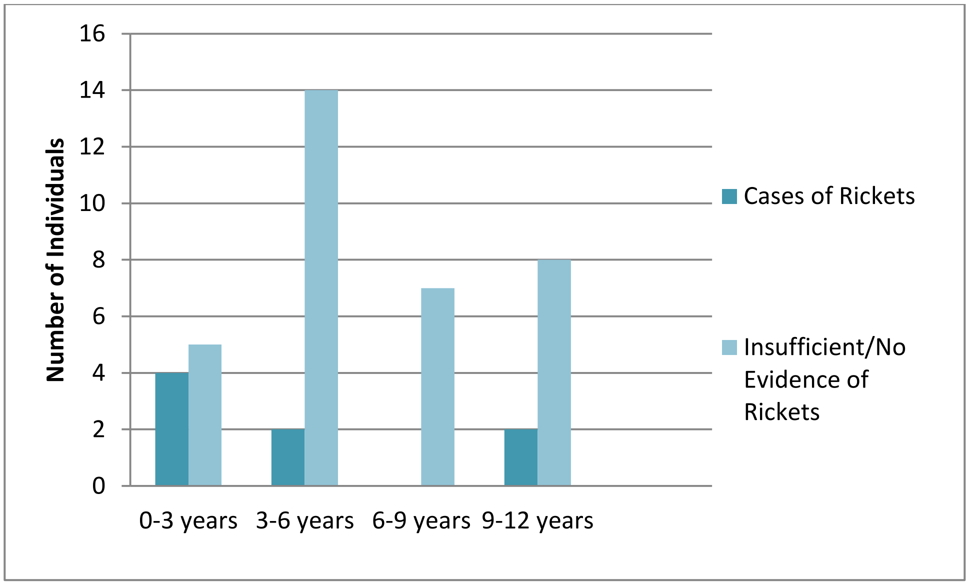
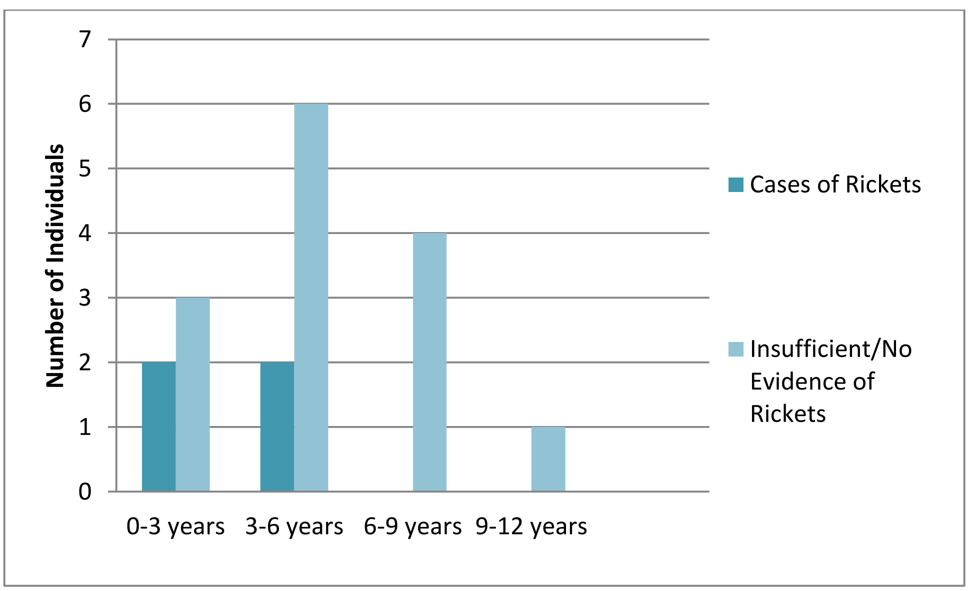


Figure 5.29– Frequency of Rickets in the Merovingian Michelet Sample



Individuals with rickets were also compared in relation to the rest of the Michelet sample in regards to long bone growth, CT, and body mass estimates. Figures 5.30 and 5.31 demonstrate the distribution of femoral lengths and CT within the entire Michelet sample. MIC 31 was identified as an outlier and has a very low femoral CT for age, as well as stunted longitudinal growth. Most other individuals are within the range of the non-rachitic subadults. Body mass estimates for four rachitic individuals (MIC 713, MIC 347, MIC 234, and MIC 141) were labelled and compared with the rest of the body mass estimates from non-rachitic subadults in Figure 5.32.

The body mass estimate from MIC 234 spans over the expected body mass values of the 0-3 year and 3-6 year category, which is fitting as the individual is 3-4 years old and represents the higher portion of the 0-3 year category and the lower expected value of the 3-6 year category. The body mass estimate for MIC 347 is within the expected range of values for the 3-6 year category. Body mass estimates for the other individuals could not be calculated.

Figure 5.30. – Scatterplot of Femoral Length vs. Dental Age, with Rachitic Individuals Labelled in Red

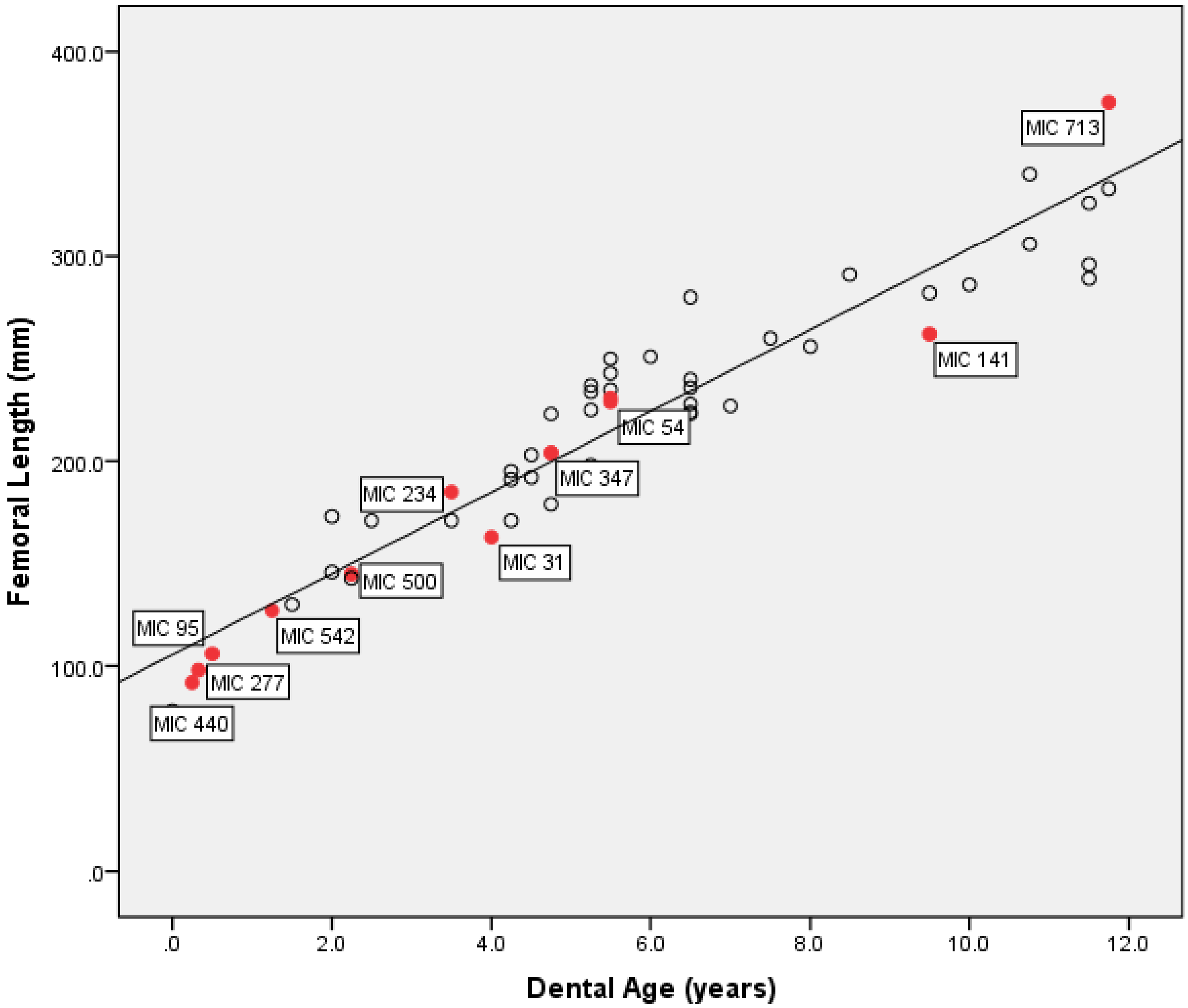


Figure 5.31 – Scatterplot of Femur CT vs. Dental Age with Rachitic Individuals Labelled in Red

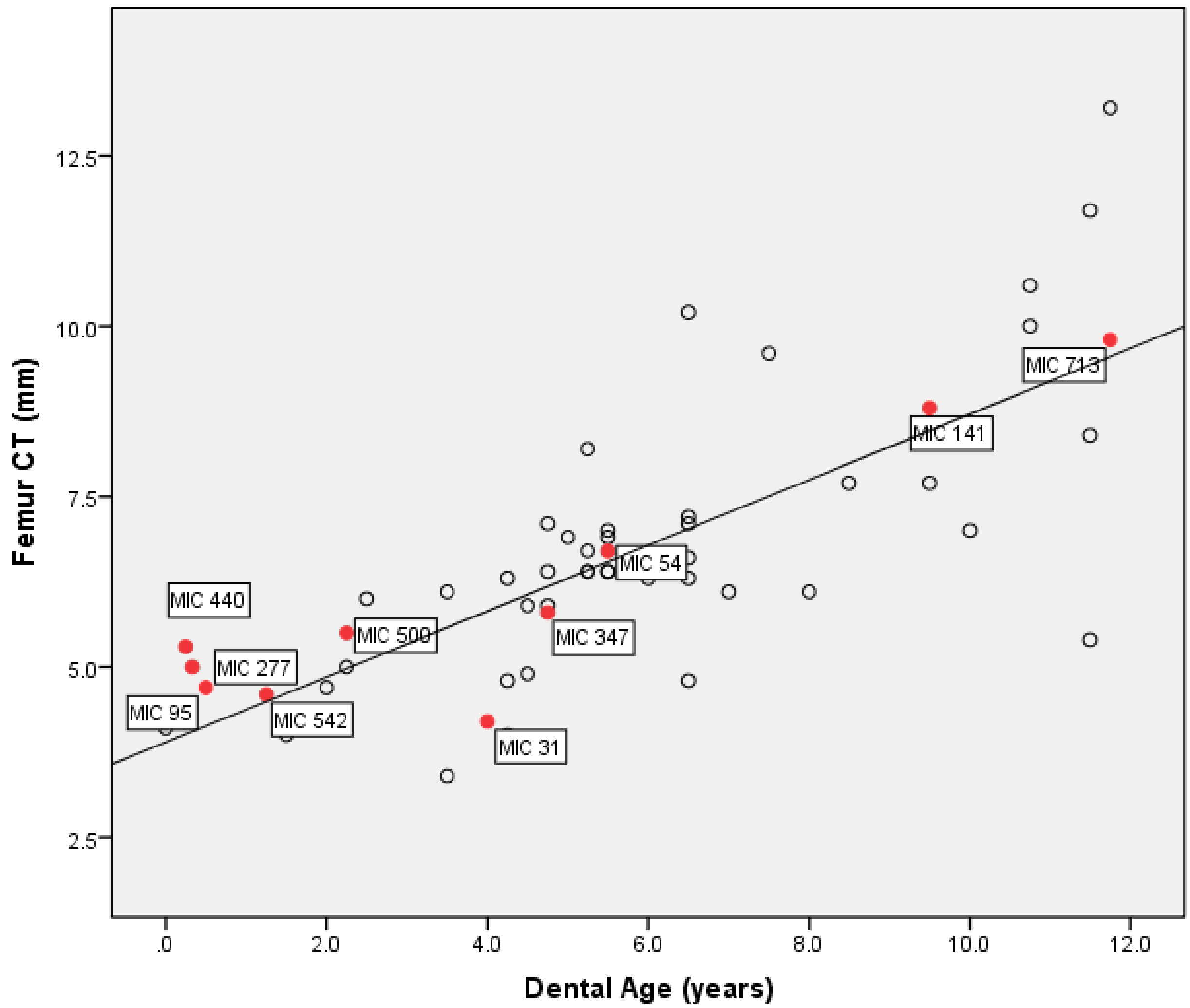
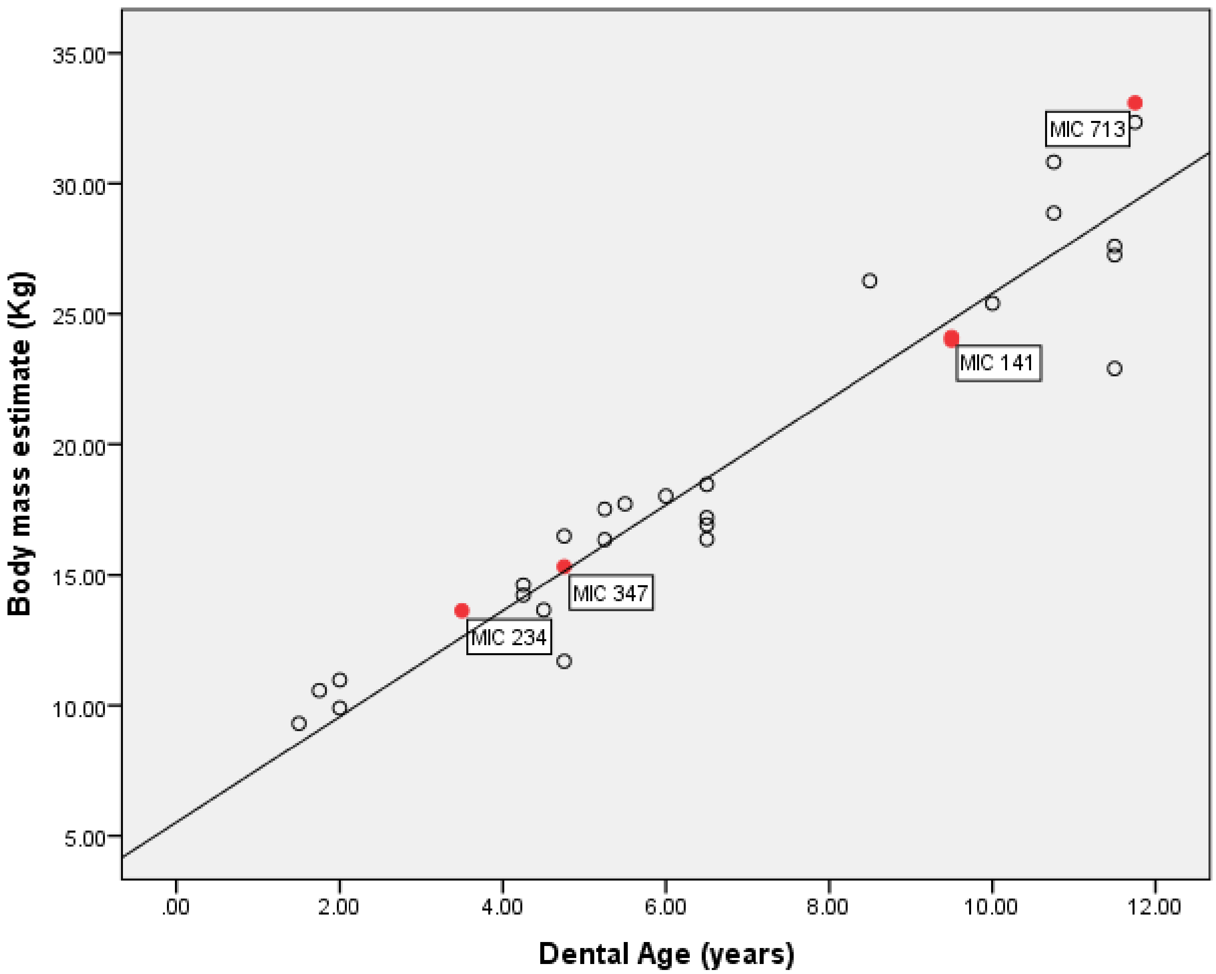


Figure 5.32 – Scatterplot of Body Mass Estimated vs. Dental Age with Rachitic Individuals Labelled in Red



Chapter 6: Discussion

6.1 Introduction

In this chapter the major findings of the investigations into longitudinal growth faltering and stunting, appositional bone growth, cortical thickness, body mass estimates, and prevalence of rickets are discussed in relation to childhood during the late Roman and Merovingian periods in Gaul. Differences between individuals interred in different burial types, and individuals with and without recorded grave goods will also be discussed. The implications of the results will be placed in the context of previous research in these areas.

6.2 Growth Delay

The results reveal that Michelet subadults were consistently smaller than expected for their age. There were significant differences between age estimations made using dental formation and eruption methods and age estimates for the same individuals using long bone length. Five different sets of age estimates for each individual, derived from long bone length, were calculated using the femur, tibia, humerus, radius and ulna for comparison against dental age estimates (Appendix A, Table 4). The difference between each age estimates was significant for each long bone. The overall average delay in skeletal growth was greatest in the tibia (1.66 years) and femur (1.58 years), and less so in the humerus (1.22 years), radius (1.40 years) and ulna (1.32 years). These results are in accordance with previous findings that growth delay is expected to be most visible in the most rapidly growing long bones; the tibia and femur (Cardoso and Magalhães 2011).

Stunting prevalence was calculated using z scores which fell below two standard deviations from the healthy reference average (Cogill 2003). The Maresh dataset of average long bone lengths was used as the healthy reference sample to calculate z scores in this study. It should be noted that prevalence rates of stunting will differ based on which reference sample is used to calculate z scores, thus direct comparisons with stunting prevalence rates from other studies must be done with caution (Schillaci et al. 2012). Stunting prevalence rates from Michelet based on the Maresh (1970) sample of healthy subadults were lowest (40%) in the youngest age category of 0-3 years, and highest (70%) in the two oldest age categories composed of individuals 6-9 years and 9-12 years of age. The larger prevalence of stunting in older age categories is reflective of sustained or repeated nutritional or environmental stresses, along with the absence of catch up growth.

The WHO reference standards also classify individuals falling between -1 and -2 standard deviations below the reference population mean as experiencing mild malnutrition (Cogill 2003). Malnutrition can result from a range of factors related to the inadequate quality of dietary intake. Undernutrition is due to insufficient caloric intake. A lack of variability in foods, or the inability to absorb nutrients from food, as well as over-consumption or under-consumption of foods can all contribute to malnutrition (Saunders and Hoppa 1993).

Scatter plots (Figs. 5.8 – 5.12) indicate that shorter long bone length for age, (or delayed growth) is evident slightly before two years of age and the disparity continues and increases through the rest of the study cohort. Pinhasi et al. (2006) note growth retardation is evident most often during the first and second year of life when growth velocity is at its peak; thus making this age group particularly vulnerable to environmental disturbances. The degree of disparity between expected and Michelet long bone length increases slightly around five years, which may reflect the inability of Michelet individuals to attain greater heights during the midgrowth spurt usually occurring around 6-8 years of age, as well as possible continued nutritional stress.

Catch up growth is difficult to identify in cross-sectional studies as skeletal assemblages do not reflect actual growth rates of individuals over time. For catch-up growth to occur a period of delayed growth must be followed by a recovery from detrimental stresses; usually nutritional or disease related. Studies have shown that an individual's ability for catch-up growth decreases with age and with the severity and duration of stress (Pinhasi et al. 2006). Scatterplots of dental age and age estimates from long bone lengths (Figs. 5.8 – 5.12) demonstrate that the disparity does not narrow in older children, but instead may increase with age. This is a consistent pattern, since environmental stressors can continue to impact skeletal growth.

These results are similar to a number of modern and bioarchaeological studies. A study from Gambia, West Africa, demonstrated that infants had similar growth rates to European standards until approximately 6-18 months when the growth rates of Gambian infants declined drastically, likely in response to high incidence levels of diarrheal disease, which was also a leading cause of death at this time (McGregor et al. 1968). In an ancestral Puebloan sample (1300 - 1680AD) Schillaci et al. (2011) found growth faltering beginning soon after birth, and noticeably around age two, with an improvement in the growth of individuals around age five. The improvement in growth also coincided with a culturally relevant social age transition during childhood from innocence, and being 'not yet human', to being an older child who was incorporated into tribal rituals (Schillaci et al. 2011). For the Michelet sample, no improvements in the growth rate were evident for this sample of non-survivors around seven years of age, indicating that nutrition and/or disease load did not improve significantly after the period of *infantia* and transition into *puer/puella.* Thus the transition of subadults at Michelet from one social age category to another did not have any positive impact on their overall growth and development.

At Poundbury Camp, a Romano-British cemetery in the United Kingdom dating to the late Roman Empire, delayed growth beginning around three months of age was suggested to be related to early weaning with inadequate nutritional supplementation leading to malnutrition and vulnerability to disease (Molleson 1989). Similar to the Michelet sample, the Poundbury subadults were not able to recover from the growth delay that started in infancy and these subadults remained smaller than expected for their age throughout their childhood; approximately two years behind their dental age (Molleson 1989). Molleson also reported that in conjunction with growth delays, the Poundbury subadults also had evidence for a reduction in cortical thicknesses (1989).

Previous studies of subadult remains have analysed growth delay in association with socio-economic status, and have used burial type and grave goods as indicators of social status (e.g., Mays et al. 2009b; Redfern et al. 2015). Cardoso (2007) demonstrated in a 20th century AD Portuguese population that endochondral growth was significantly delayed in lower status children from a 20th century AD Portuguese sample in comparison to those from higher socio-economic status families. Cardoso (2007) further noted that socio-economic status is a good indicator of social inequality and often individuals with lower socio-economic status are subject to poorer living conditions, less access to resources, and lower family incomes. Similarly, Bogin (1998) noted that in urban settings socio-economic status is often associated with differences in nutrition and living conditions. Finally, Pinhasi et al. (2006) found that socio-economic status was a significant factor in childhood growth delays in post-Medieval populations in London, England.

The results from Michelet indicate that there are no statistically significant differences between various indicators of growth and burial type, or those with and without recorded grave goods at Michelet. This may indicate that burial type and presence of grave goods are not reflective of socio-economic status in life for the study sample, or possibly that the disparity between social classes in this skeletal sample did not affect subadult growth and development. More information regarding socio-economic status was known for samples analysed by Cardoso (2007) and Mays et al. (2008), whereas less is understood about how wooden coffins, earth cut graves, and wedging stone graves may relate to socio-economic status at Michelet, if at all. Paillard (2006) did mention that individuals buried in sarcophagi would likely have been high status, but MIC 323 was the only subadult in this study sample buried within a sarcophagus. MIC 323 was approximately 1.75 years old, and this individual's humerus and ulna lengths did not deviate significantly from the Maresh (1970) reference sample, although this was typical of the youngest individuals from the sample. Similarly, the AP and CT measurements were within the normal range of the Michelet sample. The body mass estimate for this individual (found in Table 8 in Appendix A) is slightly lower than the WHO reference standard, but still within the normal range for that age group of Michelet suadults. MIC 323 is considered relatively healthy in comparison to the reference standard and other Michelet subadults, but many of the youngest individuals did not show a large degree of growth stunting in the 0-3 year age category.

It may be suggested that these differences are due to the mortality bias, that is, the skeletal sample is made up of non-survivors and may not accurately represent the living population, whereas the Maresh (1970) data are derived from a living sample of healthy subadults in North America (Maresh 1970). A study conducted by Saunders and Hoppa (1993) examined the effect of this bias and determined that non-survivors consistently had smaller diaphyseal lengths than children of the same approximate age in the Maresh (1970) sample, but concluded that these differences would be minimized in archaeological studies due to methodological issues of non-precise aging techniques (Saunders and Hoppa 1993). The growth faltering present in the Michelet subadults may be partially due to this mortality bias, but it is also likely reflective of the overall health status of these individuals.

6.3 Appositional Growth and Cortical Thickness

Appositional growth and cortical thickness in Michelet subadults also demonstrate the presence of growth disruption. A bioarchaeological study conducted by McEwan et al. (2005) found that bone length and age, and appositional growth and age were closely correlated; in contrast cortical thickness was poorly correlated with appositional growth and age. They concluded that this was a result of nutritional disturbances. Similar results were found in the Michelet sample; that bone length and age and appositional growth for age were much more closely related than cortical thickness and age. Studies that identify reduced cortical thickness during growth in the context of poor nutrition report that the reduction in thickness is a result of increased endosteal resorption instead of a reduction in bone deposition on the subperiosteal surface (Garn 1970; Mays et al. 2009b). This is evident in the Michelet sample as AP growth steadily increases through immaturity and remains strongly correlated with age, while CT is more variable and only moderately associated with age.

Box plots (Figs. 5.24, 5.25) for age categories of femoral AP and CT were created to identify outliers. While no outliers were identified for femoral AP, there were a number of outliers for femoral CT. MIC 31, MIC 423, MIC 853 all belong to the 3-6 year age category and fall below the average distribution of CT for that age group. MIC 31, which has abnormally low CT and the lowest height-for-age Z score, is one of the individuals with rickets. This individual was buried in an earth cut grave in the 4th – 5th century AD. MIC 423 and MIC 853 were similarly buried with no grave goods in wooden coffins in the 4th century AD. The three individuals with low CT for age also displayed stunted long bone growth. Two individulas had very high CT; MIC 444 and MIC 414. Both MIC 444 and MIC 414 were buried in wooden coffins during the 4th century AD with no grave goods, and are approximately aged 5-7 years old. The two individuals with high CT for age were not consdidered stunted.

At Saint Martin's, Birmingham, a 19th century church cemetery, Mays et al. (2009b) found no evidence of endochondral growth delays between low and high socio-economic status subadults (identified by grave type). They did however find that CT was significantly lower in the low socio-economic status group. The authors suggested that these differences were due to adverse nutritional conditions during growth, often associated with lower socio-economic status (Mays et al. 2009b). Tests comparing standardized residuals of femoral CT between individuals buried with and without grave goods at Michelet and between burial types attempted to see if CT varied between these groups. No significant differences were identified. The standardized residuals of femoral CT were also compared between individuals thought to date to the late Roman and Merovingian periods; similarly, no significant differences were identified. This indicates that there were no differences in growth between the time periods, suggesting that the collapse of the Roman Empire and establishment of Merovingian rule did not have a significant effect on subadult growth and development. Similarly, grave type and presence or absence of grave goods, possibly related to socio-economic status of the deceased, had no effect on growth of the Michelet subadults.

6.4 Body Mass Estimations

Body mass estimates in this sample were closely correlated to dental age. A boxplot of body mass estimates for age category (Fig. 5.26) only identified one outlier, MIC 20, as having an unusually high body mass for age. However, the individual had a dental age of 8.5 years, and had a body mass that would have belonged within the normal range of individuals 9-12 years of age. Body mass estimates of the Michelet subadults were plotted against the WHO reference standard of childhood healthy weight for age for individuals aged 0-5 years (2006) (Fig.5.27). Body masses for the Michelet subadults scored slightly below the WHO median values, but this difference was not statistically significant. Comparisons between body mass estimates for age between the late Roman and Merovingian subgroups, between individuals with and without grave goods, and those buried in different grave types were compared. A significant difference was found between individuals with and without grave goods; however, this result was not very robust, as one of the test assumptions was violated. An alternative P and T value based off of calculations when equal variances were not assumed still resulted in a significant result. Closer inspection revealed that body mass estimates for individuals with grave goods were only available from very young individuals, while many of the body mass estimates for individuals without grave goods were obtained from older subadults, likely resulting in a higher average body mass for the group with no grave goods (See Appendix A, Table 10). No other significant differences between subgroups were found.

Anthropological studies that identify growth delays in a subadult population also often identify low body mass as an indicator of poor health within a community (Pilkington 2013) and this has been identified in archaeological samples as well. In contrast to the current study, Pinhasi et al. (2014) found significant differences in body mass estimates from two contemporary Croatian populations with different environmental conditions and diets. They found that the Adriatic population, with more meat protein in their diet, attained larger body sizes than the Continental population with a diet composed mainly of millet and much less meat protein (Pinhasi et al. 2014). The same study also demonstrated that the Adriatic population that was consuming more meat protein also had larger bone lengths for age (Pinhasi et al. 2014). It may be postulated that since no reliable significant differences were found between subgroups in this sample, nutrition and amounts of protein in the diet of subadults from Michelet did not differ significantly between individuals.

6.5 Rickets

Approximately 9.2% (N=12/130) of the subadults analysed from this sample exhibited skeletal evidence for rickets. Many of the rachitic individuals were very young; 5 of 12 of the rachitic individuals were estimated to be under one year old. The oldest individuals represented healed cases, while the younger cohort had active cases at the time of death (Table 5.33). It is likely that the practice of swaddling new born infants, common in the Roman and Merovingian periods (Orme 2001; Rawson 2003; Croom 2010), limited sunlight exposure and the production of vitamin D for the youngest age cohort at Michelet. It is also possible that low levels of vitamin D in breastmilk, whether through the biological mother or wet nurse impacted levels of vitamin D deficiency in infants (Brickley and Ives 2008; Brickley et al. 2014). A study from Roman Italy demonstrated that the introduction of supplementary foods in that population likely occurred around 6-12 months old (Prowse 2011). Weaning foods including cereals high in phytates, and foods low in calcium are also likely to have exacerbated the pathological manifestation of rickets in very young individuals (Brickley and Ives 2008; Redfern and DeWitte 2011).

The northern European climate would also likely have been conducive to the development of rickets. Paris, France has been recorded as receiving only 1779 hours of sunlight on average, per year (Climate Data http://www.climatedata.eu/ climate.php?loc=frxx0076&lang=en accessed April 2016). Clothing suited for seasonally cooler temperatures in northern France would have also limited cutaneous exposure to sunlight for the small number of children who were more mobile, but still exhibited evidence for vitamin D deficiency. Historians related that children likely wore many layers of clothing including tunics, leggings, scarfs and capes; likely covering large amounts of skin from the available sunlight (Orme 2001; Croom 2010).

Diets high in phytates introduced first as cereals in weaning supplements, also likely made up a large portion of older children's diets and may have disrupted calcium homeostasis within the body. Future research would benefit from an isotopic analysis of the population at Michelet; it may reveal the importance of marine resources in children's diets. Oily fish containing small amounts of vitamin D may have helped ward off the deficiency for some individuals. The settlement was not located directly on the coast, but may have had access to marine and riverine resources (Paillard 2006).

A recent study by Redfern et al. (2015) found a higher prevalence of rickets in an urban skeletal sample compared to a rural one in Romano-British Dorset, possibly indicating that urban architecture and lifestyles may have also influenced exposure to sunlight. The small number of older children at Michelet with evidence of healed rickets at the time of death demonstrates that younger children who experienced deficiency recovered and survived for a number of years afterward.

Lewis (2010) reported high levels of rickets at the urban late Romano British cemetery of Poundbury Camp in Dorcester, Dorset (3rd – 5th century AD). The study reported a prevalence rate of 12.5% that affected mostly infants. The study cites swaddling and poor weaning diets as probable causes. It is likely that similar factors contributed to the similarly high prevalence of rickets (9%) in the Michelet sample of subadults. Mays et al. (2006) found that approximately 13% of subadults had pathological features indicative of rickets from a 19th century, urban population from St. Martin's Churchyard in Birmingham, England. Individuals affected at St. Martin's were also quite young ranging from three months to 4.5 years old. Pollution from industrial manufacturing, urban architecture with narrow alleyways are cited as the most influential factors responsible for the high prevalence at St. Martin's (Mays et al. 2006).

Research conducted by Pinhasi et al. (2006) demonstrated that individuals with rickets in Medieval and Post-Medieval samples did not have significantly smaller long bone lengths than their counterparts with no evidence of vitamin D deficiency. Conversely, a similar study by Mays et al. (2009a) demonstrated that subadults with rickets from the 19th century St. Martins Church, had significantly smaller limb lengths than their counterparts. Mays et al. (2009a) suggested that this was due to a combination of delayed growth and long bone bowing. At Michelet, rachitic individuals were not significantly smaller than their counterparts, which reflect the results of the Pinhasi et al. (2006) study. It is possible that retarded growth in the rachitic individuals is not as perceptible in this sample as the majority of Michelet subadults already had smaller than expected long bone lengths for age. There were bending deformities in a number of long bones in the rachitic Michelet subadults, but when present bowing in this sample was slight, not marked, and so likely would not have greatly affected overall long bone length.

Appositional growth and cortical thicknesses from rachitic individuals are within the normal range of values expected in the Michelet sample. Body mass estimates available for a small number of those rachitic individuals are also within the expected, normal ranges. It is possible that the estimates based on the femoral distal metaphysis breadth are somewhat inflated as flaring of the distal metaphysis is a feature of vitamin D deficiency and present in four of the Michelet subadults; MIC 234 is the only one of these individuals with a body mass estimate. The body mass estimate for MIC 234 is within the normal range for Michelet individuals. There are slightly more rachitic individuals belonging to the late Roman period than from the Merovingian period; this should be expected as a larger proportion of individuals in the cemetery date from the late Roman period. A chi square test revealed that individuals with rickets were evenly distributed between the two periods based on sample sizes. In other words, the observed and expected frequencies of rickets were the same. There seems to be no patterns in terms of individuals affected with or without grave goods, or those in different grave types. This may indicate that, if these markers do indicate some information regarding socio-economic status (SES), that SES did not buffer against vitamin D deficiency.

6.6 Childhood Growth in a Late Roman and Merovingian Context

Both clinical and bioarchaeological studies agree that nutritional stress, particularly protein deficient diets, are directly related to cortical thinning, stunted long bone growth, and low body mass for age (McEwan et al. 2005; Mays et al. 2009b; Pinhasi et al 2014). The high degree of variability of CT in the Michelet subadults, as well as evidence for delayed longitudinal growth, and lower body masses for age compared to WHO standards, all support the notion that the subadults buried at Michelet experienced nutritional stresses during their lifetime. Inadequate nutrition and exposure to disease are critical factors that can lead to the slowing of the growth rate and result in the inability to reach maximum growth potential (Scheuer and Black 2004). It is well established that a synergistic relationship exists between disease and malnutrition. Extended malnutrition weakens the immune system, making children more susceptible to diseases including diarrheal disease which inhibits the body from effectively absorbing nutrients, leading to exacerbated malnutrition (Pilkington 2013). Archaeological evidence suggests that grain-based foods made up a significant portion of the Roman diet (Pilkington 2013). Pilkington (2013) noted that cereals are nutritious but do not meet the needs of adult women and children with little to no supplementation of other foods.

Statistical tests demonstrated that there were no reliable significant differences between growth trajectories of late Roman and Merovingian children in this study. Tests to see if there were differences between appositional growth, acquisition of cortical thickness, and estimates of body mass also all demonstrated there were no significant changes between the two time periods. Both samples did, however, display growth delays beginning shortly before two years of age and had small long bone lengths for age. It is possible that between the late Roman and Merovingian period there were no radical shifts or changes in nutrition or overall health status.

Historians write that the late Roman and Merovingian period was a time of political instability, and it is unclear exactly how the fall of Rome, barbarian invasions, or the rise of the Merovingian kingdom impacted the health of children buried at Michelet. Based on continuities in growth faltering, CT variability, low body masses, and equal distribution of rickets life may have remained relatively stable for these children through these political shifts. Additionally, concepts of childhood and expected age related behaviours were likely very similar between these two periods which may have supported cultural continuity in health determinants over time.

Chapter 7: Conclusions

Historical sources indicate that the period during the fall of the Roman Empire, rise of barbarian groups and the ultimate the ascension of the Merovingian kingdoms was tumultuous (Drinkwater and Elton 2002), but it is unknown how these events affected the late Roman and Merovingian city of *Noviomagus Lexovii* (Paillard 2006). Macroscopic and radiographic analysis of subadult skeletal materials from this period permitted the investigation of a number of measures of growth and development to determine how a period of socio-political upheaval may have affected the health status of this population.

The aims of this study were to identify growth disruptions using a number of different measures of growth, establish the frequency of rickets in the sample, and determine if there were any differences in growth between time periods, individuals with or without grave goods and those in different burials types. The current study also attempted to contribute to an understanding of the interpretation of health at the Michelet necropolis, and the social, cultural, and environmental circumstances that may have impacted health in the past.

The current study reported a relatively high prevalence of stunting, initially becoming evident in individuals two years and older, with older individuals demonstrating a greater magnitude of stunting than younger individuals. Unlike the Schillaci et al. (2011) results that show a period of recovered growth and improved health during a culturally significant transition during childhood in an ancestral Puebloan group, no such recovery was demonstrated in the Michelet sample during the transition from the *infantia* social age category to the *puer/puella* category.

Cortical thickness (CT) was highly variable and only moderately correlated with dental age for each long bone. This wide range of CT variation, combined with AP values that steadily increased with age, demonstrated that some individuals experienced cortical thinning, but no distinct pattern of which individuals were most affected was evident. Body mass estimates were also demonstrably lower in subadults from Michelet when compared to the WHO growth standards (2006) though this difference was not statistically significant. A number of statistical tests determined that there were no reliable significant differences in any of the measures of growth analysed in this study between the late Roman and Merovingian periods, between individuals buried with or without grave goods, or in relation to grave type.

A total of 12 out of 130 individuals exhibited convincing evidence for rickets. The frequency and distribution of rickets revealed that the same proportion of individuals were affected from the late Roman and Merovingian periods, suggesting continuity of social and cultural behaviours related to the development of the deficiency. Pathological lesions were most numerous in very young individuals, while older subadults displayed healed cases. Swaddling and low vitamin D content in utero and/or in breastmilk likely contributed to the development of rickets in this sample. Similar to the Pinhasi et al. (2006) study, there was no significant difference in growth delay between individuals with or without rickets.

These results demonstrated a number of factors which impacted the health of the subadults interred at the Michelet necropolis. Nutritional stresses related to poor or unbalanced diets likely contributed to the high prevalence rates of stunting and cortical thinning in this sample. The northern location, urban architecture, swaddling practices, poor weaning diets, and low maternal levels of vitamin D in utero and in breastmilk include the environmental and cultural factors which likely contributed to the high prevalence rate of rickets at Michelet. The social and economic disruption that historians note during this transition period appeared to have no effect on the health status of the subadults from the Michelet necropolis as no significant differences in growth or prevalence of rickets was found between the two periods.

In summary, a large collection of skeletal remains permitted an in-depth bioarchaeological analysis of childhood health during the late Roman and Merovingian period in Gaul. Findings point to a stressed population with nutritional deficiencies present throughout childhood. No differences in growth or growth disruption between the two periods, indicates that daily life and health for the children of *Noviomagus Lexovii* was not drastically altered during the fall of the Roman Empire and rise of Merovingian kingdoms.

References Cited

Bleiber W. 1996. The Merovingian Kingdom. In Herrmann J, Zürcher E. (eds.) History of Humanity: Volume III: From the seventh century B.C. to the seventh century A.D. New York: Routledge. p. 258-262.

Bloomer W. 2013. The Ancient Child in School. In Evans Grubbs J, Parkin T, Bell R. (Eds.). The Oxford Handbook of Childhood and Education in the Classical World. Oxford: Oxford University Press. p. 444-464.

Bogin B. 2001. The Growth of Humanity. New York: John Wiley & Sons, Inc.

Bogin B. 1999. Patterns of Human Growth. (2nd Ed.). Cambridge: Cambridge University Press.

Bogin B. 1998. Social and Economic Class. In Ulijaszek S, Johnston F, Preece M. (Eds.) The Cambridge Encyclopedia of Human Growth and Development. Cambridge: Cambridge University Press. p. 399-401.

Brickley M, Ives R. 2008. The Bioarchaeology of Metabolic Bone Disease. Oxford: Academic Press.

Brickley M, Moffat T, Watamaniuk L. 2014. Biocultural Perspectives of Vitamin D Deficiency in the Past. Journal of Anthropological Archaeology 36:48-59.

Buikstra J, Ubelaker D. 1994. Standards for Data Collection from Human Skeletal Remains. Arkansas: Arkansas Archaeological Survey Research Series.

Callow C, Harlow M. 2012. Left-over Romans: the Lifecourse in the Late Antique West. In Harlow M, Loven L. (Eds.). Families in the Roman and Late Antique West. New York: Continuum International Publishing Group. p. 221-238.

Cardoso H. 2007. Environmental Effects on Skeletal Versus Dental Development: Using a Documented Subadult Skeletal Sample to Test a Basic Assumption in Human Osteological Research. American Journal of Physical Anthropology 132:223-233.

Cardoso H, Garcia S. 2009. The Not-so-Dark Ages: Ecology for Human Growth in Medieval and Early Twentieth Century Portugal as Inferred from Skeletal Growth Profiles. American Journal of Physical Anthropology 138:136-147.

Cardoso H, Magalhães T. 2011. Evidence of Neglect from Immature Human Skeletal Remains: An Auxological Approach from Bones and Teeth. In Ross A, Abel S. (Eds.).

The Juvenile Skeleton in Forensic Abuse Investigations. New York: Humana Press. p. 125-150.

Carroll M. 2011. Infant Death and Burial in Roman Italy. Journal of Roman Archaeology 24:99-120.

Cogill B. 2003. Anthropometric Indicators Measurement Guide. Food and Nutrition Technical Assistance Project, Academy for Educational Development, Washington DC.

Collins R. 2010. Early Medieval Europe, 300-1000. (3rd Ed.). New York: Palgrave MacMillan.

Conceição E, Cardoso H. 2011. Environmental Effects on Skeletal Versus Dental Development II: Further Testing of a Basic Assumption in Human Osteological Research. American Journal of Physical Anthropology 144:463-470.

Croom A. 2010. Roman Clothing and Fashion. Gloucestershire: Amberley Publishing.

DeLucia M, Mitnick M, Carpenter T. 2003. Nutritional Rickets with Normal Circulating 25-Hydroxyvitamin D: A Call for Re-examining the Role of Dietary Calcium Intake in North American Infants. The Journal of Clinical Endocrinology & Metabolism 88: 3539-3545.

Demay M, Krane S. 2010. Disorders of Calcification: Osteomalacia and Rickets. In Jameson J, De Groot L. (6th Ed.). Endocrinology: Adult and Pediatric, Volume I. Philadelphia: Elsevier Health Sciences. p. 1131-1329.

Dimitri P, Bishop N. 2007. Rickets. Paediatrics and Child Health 17:279-287.

Drinkwater J, Elton H. 2002. Fifth-Century Gaul: A Crisis of Identity? Cambridge: Cambridge University Press.

Fontaine J. 1996.Chritianity and the Christian Church between 284 and 476. In Herrmann J, Zürcher E. (Eds.). History of Humanity: Volume III: From the seventh century B.C. to the seventh century A.D. New York: Routledge. p. 235-240.

Frisancho A, Guire K, Babler W, Borkan G, Way A. 1980. Nutritional Influence on Childhood Development and Genetic Control of Adolescent Growth of Quechuas and Mestizos from the Peruvian Lowlands. American Journal of Physical Anthropology 52:367-375.

Garn S. 1970. The Earlier Gain and Later Loss of Cortical Bone. Springfield, Illinois: Charles C. Thomas.

Gilchrist R. 2008. Archaeology and the Life Course: A Time and Age for Gender. In Meskell L, Preucel R. (Eds.). A Companion to Social Archaeology. New York: Blackwell Publishing. p. 142-160.

Goodman A, Armelagos G. 1989. Infant and Childhood Morbidity and Mortality Risks in Archaeological Populations. World Archaeology 21:225-243.

Gustafson G, Koch G. 1974. Age estimation up to 16 years of age based on dental development. Ondontologisk Revy 25:297-306.

Halcrow S, Tayles N. 2008. The Bioarchaeological Investigation of Childhood and Social Age: Problems and Prospects. Journal of Archaeological Method and Theory 15:190-215.

Harlow M, Laurence R. 2002. Growing Up and Growing Old in Ancient Rome. New York: Routledge.

Holick M. 2008. Vitamin D: a D-Lightful Health Perspective. Nutrition Reviews 66(Suppl. 2): S182-S194.

Hoppa R, Fitzgerland C. 1999. Human Growth in the Past: Studies from Bones and Teeth. Cambridge: Cambridge University Press.

Hummert J. 1983. Cortical Bone Growth and Dietary Stress Among Subadults From Nubia's Batn El Hajar. American Journal of Physical Anthropology 62:167-176.

Humphrey L. 2003. Linear Growth Variation in the Archaeological Record. In Thompson J, Krovitz G, Nelson A. (Eds.). Patterns of Growth and Development in the Genus *Homo*. Cambridge: Cambridge University Press. p. 144-169.

James E. 2004. Childhood and youth in the Early Middle Ages. In Goldberg P, Riddy F. (Eds.): Youth in the Middle Ages. Suffolk: York Medieval Press. p. 11-24.

Jokar M, Hetef Fard M, Mirfeizi Z. 2008. Rickets and Osteomalacia in Northeast Iran: Report of 797 Cases. International Journal of Rheumatic Diseases 11:170-174.

Keith M. 1981. Cortical Bone Loss in Juveniles of Dickinson Mounds. Research Report 20: Biocultural Adaptation Comprehensive Approach to Skeletal Analysis. Paper 8: 64-77.

King S, Ulijaszek S. 1999. Invisible Insults During Growth and Development: Contemporary Theories and Past Populations. In Hoppa R, FitzGerald C. (Eds.). Human Growth in the Past: Studies from Bones and Teeth. Cambridge: Cambridge University Press. p. 161-182.

Kuklina E, Ramakrishnan U, Stein A, Barnhart H, Martorell R. 2006. Early Childhood Growth and Development in Rural Guatemala. Early Human Development 82:425-433.

Lewis M. 2007. The Bioarchaeology of Children: Perspectives from Biological and Forensic Anthropology. Cambridge: Cambridge University Press.

Lewis M. 2010. Life and Death in a Civitas Capital: Metabolic Disease and Trauma in the Children from Late Roman Dorchester, Dorset. American Journal of Physical Anthropology 142: 405-416.

Leyerle B. 2013. Children and "The Child" in Early Christianity. In Grubbs J, Parkin T, Bell R. (Eds.): The Oxford Handbook of Childhood and Education in the Classical World. Oxford: Oxford University Press. p. 559-579.

Malina R, Reyes M, Little B. 2009. Socioeconomic Variation in the Growth Status of Urban School Children 6-13 Years in Oaxaca, Mexico, in 1972 and 2000. American Journal of Human Biology 21: 805-816.

Maresh M. 1970. Measurements from Roentgenograms, Heart Size, Long Bone Lengths, Bone, Muscles and Fat Widths, Skeletal Maturation. In: McCammon R. (Ed.). Human growth and development. Springfield: Charles C. Thomas. p. 155-200.

Markestad T. 2012. Rickets. In Elzouki A, Harfi H, Stapleton F, Nazer H, Oh W, Whitley R. (2nd Ed.) (Eds.). Textbook of Clinical Paediatrics Volume I. New York: Springer Science & Business Media. p. 757-768.

Mays S. 1999. Linear and Appositional Long Bone Growth in Earlier Human Populations: a Case Study From Mediaeval England. In Hoppa R, FitzGerald C. (Eds.). Human Growth in the Past: Studies from Bones and Teeth. Cambridge: Cambridge University Press. p. 290-312.

Mays S, Brickley M, Ives R. 2006. Skeletal Manifestations of Rickets in Infants and Young Children in a Historic Population From England. American Journal of Physical Anthropology 129:362-374.

Mays S, Brickley M, Ives R. 2008. Growth in an English Population From the Industrial Revolution. American Journal of Physical Anthropology 136: 85-92.

Mays S, Brickley M, Ives R. 2009a. Growth and Vitamin D Deficiency in a Population from 19th Century Birmingham, England. International Journal of Osteoarchaeology 19:406-415.

Mays S, Ives R, Brickley M. 2009b. The Effects of Socioeconomic Status on Endochondral and Appositional Bone Growth, and Acquisition of Cortical Bone in

Children From 19th Century Birmingham, England. American Journal of Physical Anthropology 140:410-416.

Mays S, Brickley M, Ives R. 2006. Skeletal Manifestations of Rickets in Infants and Young Children in a Historic Population From England. American Journal of Physical Anthropology 129:362-374.

Mathisen R. 2006. People, Personal Expression, and Social Relations in Late Antiquity, Volume II. Ann Arbor: The University of Michigan Press.

McCormick M. 2006. Frankish Victory Celebrations. In Noble T. (Ed.). From Roman Provinces to Medieval Kingdoms. New York: Routledge. p. 345-357.

McEwan J, Mays S, Blake M. 2005. The Relationship of Bone Mineral Density and Other Growth Parameters to Stress Indicators in a Medieval Juvenile Population. International Journal of Osteoarchaeology 15:155-163.

McGregor I, Rahman A, Thompson B, Billewicz W, Thomson A. 1968. The Growth of Young Children in a Gambian Village. Transactions of the Royal Society of Tropical Medicine and Hygiene 62:341-352.

Miyako K, Kinjo S, Kohno H. 2005. Vitamin D Deficiency Rickets Caused by Improper Lifestyle in Japanese Children. Pediatrics International 47:142-146.

Molleson T. 1989. Social Implications of Mortality Patterns of Juveniles from Poundbury Camp, Romano-British Cemetery. Anthropologischer Anzeiger 47:27-38.

Mustafa Z, Al-Madan M, Al-Majid H, Al-Muslem S, Al-Ateeq S, Al-Ali A. 2007. Vitamin D Deficiency and Rickets in the Eastern Province of Saudia Arabia. Annals of Tropical Paediatrics 27:63-67.

Noble T. 2006. From Roman Provinces to Medieval Kingdoms. New York: Routledge.

Orme N. 2001. Medieval Children. London: Yale University Press.

Ortner D, Mays S. 1998. Dry-bone Manifestations of Rickets and Infancy and Early Childhood. International Journal of Osteoarchaeology 8:44-55.

Paillard D, Alduc-le Bagousse A, Buchet L, Blondiaux J, Niel C. 2009. Identité Sociale Ou Miroir D'une Société En Evolution? Les Tombs Remarquables de la Second Moitié Du IVe Siécle Dans la Nécropole Michelet A Lisieux (Calvados). Dans Inhumations de Prestige ou Prestige de l'inhumation? Publications du CRAHAM. p.1-22.

Paillard, D. 2006. The Michelet Site. Unpublished site report.

Perry M.A. 2006. Redefining Childhood through Bioarchaeology: Toward an Archaeological and Biological Understanding of Children in Antiquity. Archaeological Papers of the American Anthropological Association 15:89-111.

Pettifor J. 2004. Nutritional Rickets: Deficiency of Vitamin D, Calcium, or Both? The American Journal of Clinical Nutrition 80(Suppl.):1725S-9S.

Pilkington N. 2013. Growing Up Roman: Infant Mortality and Reproductive Development. Journal of Interdisciplinary History 44:1-35.

Pinhasi R, Shaw P, White B, Ogden A. 2006. Morbidity, Rickets and Long-bone Growth in Post-Medieval Britain – A Cross-Population Analysis. Annals of Human Biology 33:372-389.

Pinhasi R, Timpson A, Thomas M, Slaus M. 2014. Bone Growth, Limb Proportions, and Non-specific Stress in Archaeological Populations from Croatia. Annals of Human Biology 41:127-137.

Prowse T. 2011. Diet and Dental Health Through the Lifecourse in Roman Italy. In Agarwal S, Glencross B. (Eds.). Social Bioarchaeology. Oxford: Wiley-Blackwell. p. 410-437.

Rawson B. 2003. Children and Childhood in Roman Italy. Oxford: Oxford University Press.

Redfern R, DeWitte S, Pearce J, Hamlin C, Egging Dinwiddy K. 2015. Urban-Rural Differences in Roman Dorset, England: A Bioarchaeological Perspective on Roman Settlements. American Journal of Physical Anthropology 157:107-120.

Redfern R, Gowland R. 2012. A Bioarchaeological Perspective on the Pre-adult Stages of the Life Course: Implications for the Care and Health of Children in the Roman Empire. In Harlow M, Larsson Lovén L. (Eds.). Families in the Roman and Late Antique World. London: Continuum International Publishing Group. p. 111-140.

Redfern R, DeWitte S. 2011. Status and Health in Roman Dorset: The Effect of Status on Risk of Mortality in Post-Conquest Populations. American Journal of Physical Anthropology 146:197-208.

Reitsema L, McIlvaine B. 2014. Reconciling “Stress” and “Health” in Physical Anthropology: What can Bioarchaeologists Learn from the Other Subdisciplines? American Journal of Physical Anthropology 155:181-185.

Ruff C. 2007. Body Size Prediction From Juvenile Skeletal Remains. American Journal of Physical Anthropology 133:698-716.

Ruff C, Garofalo E, Holmes M. 2013. Interpreting Skeletal Growth in the Past from a Functional and Physiological Perspective. American Journal of Physical Anthropology 150:29-37.

Saunders S, Hoppa R. 1993. Growth Deficit in Survivors and Non-Survivors: Biological Mortality Bias in Subadult Skeletal Samples. Yearbook of Physical Anthropology 36:127-151.

Saunders S, Hoppa R, Southern R. 1993. Diaphyseal Growth in a Nineteenth Century Skeletal Sample of Subadults from St. Thomas Church, Belleville, Ontario. International Journal of Osteoarchaeology 3:265-281.

Schattmann A. 2014. The Co-occurrence of Scurvy and Rickets in 16th to 18th century Skeletal Material from Douai, France. MA Thesis unpublished, Department of Anthropology, McMaster University. Hamilton, Canada.

Schillaci M, Sachdev H, Bhargava S. 2012. Technical Note: Comparison of the Maresh Reference Data with the WHO International Standard for Normal Growth in Healthy Children. American Journal of Physical Anthropology 147:493-498.

Schillaci M, Nikitovi D, Akins N, Tripp L, Palkovich A. 2011. Infant and Juvenile Growth in Ancestral Pueblo Indians. American Journal of Physical Anthropology 145:318-326.

Scheuer L, Black S. 2004. The Juvenile Skeleton. London: Elsevier Academic Press.

Séguy I, Buchet L. 2013. Examples of Archaeological Applications. In Handbook of Paleodemography Vol. 2. Switzerland: Springer International Publishing. p. 177-214.

Shore R, Chesney R. 2013. Rickets: Part I. Pediatric Radiology 43:140-151.

Sofaer J. 2011. Towards a Social Bioarchaeology of Age. In Agarwal S, Glencross B. (Eds.). Social Bioarchaeology Oxford: Wiley-Blackwell. p. 286-311.

Southon E. 2012. Fatherhood in Late Antique Gaul. In Harlow M, Loven L. (Eds.). Families in the Roman and Late Antique West. New York: Continuum International Publishing Group. p. 238-253.

Thacher T, Fischer P, Pettifor J. 2002. The Usefulness of Clinical Features to Identify Active Rickets. Annals of Tropical Paediatrics 22:229-237.

Thacher T, Fischer P, Pettifor J, Lawson J, Manaster B.J., Reading J. 2000. Radiographic Scoring Method for the Assessment of the Severity of Nutritional Rickets. Journal of Tropical Pediatrics 46: 132-139.

Thacher T, Fischer P, Strand M, Pettifor J. 2006. Nutritional Rickets Around the World: Causes and Future Directions. Annals of Tropical Paediatrics 26:1-6.

Todman D. 2007. Childbirth in Ancient Rome: From Traditional Folklore to Obstetrics. Australian and New Zealand Journal of Obstetrics and Gynaecology 47:82-85.

Vercellotti G, Piperata B, Agnew A, Wilson W, Dufor D, Reina J, Boano R, Justus H, Spencer Larsen C, Stout S, Sciulli P. 2014. Exploring the Multidimensionality of Stature Variation in the Past Through Comparisons of Archaeological and Living Populations. American Journal of Physical Anthropology 155:229-242.

Vuolanto V. 2013. Elite Children, Socialization, and Agency in the Late Roman World. In Grubbs J, Parkin T, Bell R. (Eds.): The Oxford Handbook of Childhood and Education in the Classical World. Oxford: Oxford University Press. p. 580-599.

Wacker M, Holick M. 2013. Sunlight and Vitamin D. Dermato-Endocrinology 5:51-108.

WHO. 1995. Physical Status: the use and interpretation of anthropometry. Geneva: World Health Organization.

WHO. 2006. Multigrowth Reference Study Group. WHO Child Growth Standard: Height for age, Weight-for –age, Weight-for-length, Weight-for-height and Body Mass Index-for-age, Geneva: World Health Organization.

WHO. 2014. Basic Documents (48th Ed.) Italy, World Health Organization

Wood J, Milner G, Harpending C, Weiss K. 1992. The Osteological Paradox: Problems of Inferring Prehistoric Health from Skeletal Samples. Current Anthropology 33:343-370.

Zuckerman M, Turner B, Armelagos G. 2012. Evolutionary Thought in Paleopathology and the Rise of the Biocultural Approach. In Grauer A. (Ed.). A Companion to Paleopathology. Oxford: Wiley Blackwell Press. p.34-57.

Appendix A

Table 1 – Gustafson and Koch (1974) Results for Deciduous Dentition **

Individual	*Dental Age	Location	1st incisor	2nd incisor	Canine	1st molar	2nd molar
MIC 7	0.00	U	-	-	-	-	-
		L	1.5	1.5	-	1	1
MIC 18B	5.00	U	-	-	-	3.5	3.5
		L	-	-	-	-	-
MIC 20	8.50	U	-	-	-	4	4
		L	3	-	-	-	-
MIC 26	0.00	U	-	-	-	-	-
		L	1.5	1.5	1.5	1	1
MIC 31	4.00	U	4	4	3.5	3.5	3.5
		L	-	-	-	-	-
MIC 51	6.00	U	4	4	-	4	4
		L	-	-	-	-	-
MIC 58	5.25	U	-	-	4	4	4
		L	4	4	4	-	4
MIC 75	7.50	U	-	-	-	3.5	3.5
		L	-	-	3.5	3.5	3.5
MIC 91	6.50	U	-	-	-	-	4
		L	-	-	-	-	-
MIC 111	2.50	U	4	4	3.5	3.5	3.5
		L	4	4	-	-	3.5
MIC 123	1.50	U	-	4	2.5	3.5	2.5
		L	-	-	2.5	-	2.5
MIC 129	11.75	U	-	-	-	-	-
		L	-	-	-	-	-
MIC 138	6.50	U	-	-	4	4	4
		L	4	-	4	4	4
MIC 141	9.50	U	-	-	4	4	-
		L	-	-	-	-	-
MIC 143	10.00	U	-	-	-	-	4
		L	-	-	-	-	-
MIC 178	1.50	U	3.5	3.5	3	3.5	2.5
		L	-	3.5	-	-	-
MIC 183C	4.75	U	4	-	-	3.5	3.5
		L	-	-	3.5	3.5	3.5

MIC 186A	2.00	U	3.5	3.5	3.5	3.5	3.5
		L	-	-	-	-	-
MIC 197	2.00	U	3.5	3.5	3.5	3.5	3.5
		L	3.5	-	-	-	-
MIC 205B	5.50	U	-	-	-	3.5	3.5
		L	-	-	-	-	-
MIC 225	4.50	U	4	4	3.5/4	3.5/4	3.5/4
		L	-	4	4	-	-
MIC 245	9.5	U	-	-	-	3.5/4	4
		L	-	-	-	4	-
MIC 251B	0.00	U	-	-	-	-	-
		L	-	1.5	-	1	-
MIC 253	2.25	U	-	3.5	-	3.5	3.5
		L	3.5	-	3.5	3.5	3.5
MIC 256	4.50	U	-	-	4	4	4
		L	4	4	-	-	-
MIC 258	4.50	U	-	-	4	3.5/4	3.5/4
		L	4	4	4	4	3.5/4
MIC 275	5.25	U	-	-	4	-	-
		L	4	4	4	3.5	3.5
MIC 319	11.50	U	-	-	-	-	4
		L	-	-	-	-	-
MIC 323	1.75	U	3.5	3.5	3.5	3.5	3.5
		L	3.5	-	3.5	-	3.5
MIC 331	6.50	U	-	4	4	-	4
		L	4	4	4	-	-
MIC 347	4.75	U	-	4	4	4	4
		L	-	-	-	-	-
MIC 389	11.50	U	-	-	-	-	-
		L	-	-	-	-	-
MIC 408	4.25	U	3.5	4	3.5/4	3.5	3.5
		L	-	-	-	3.5	3.5
MIC 414	6.50	U	-	-	4	-	4
		L	-	-	-	-	-
MIC 423	4.25	U	4	4	4	3.5	3.5
		L	4	4	-	-	-
MIC 433	6.50	U	-	4	4	4	4
		L	-	-	4	-	-
MIC 435	8.00	U	-	-	-	-	-
		L	4	4	-	4	4
MIC 440	0.25	U	2	2	1	1	1
		L	2	2	1	1	1

MIC 444	5.25	U	4	4	-	4	4
		L	4	4	4	4	4
MIC 467	7.00	U	-	-	4	-	4
		L	-	-	-	-	-
MIC 485A	6.50	U	-	-	-	-	-
		L	-	4	4	3.5	3.5
MIC 493	9.50	U	-	-	-	-	4
		L	-	4	4	-	4
MIC 500	2.25	U	4	4	3.5	-	3.5
		L	-	-	-	-	-
MIC 540	5.50	U	-	-	-	4	-
		L	-	-	3.5	3.5	-
MIC 542	1.25	U	3	3	2/2.5	3.5	1.5
		L	3	3	2.5	3	1.5
MIC 616	11.50	U	-	-	-	-	-
		L	-	-	-	-	-
MIC 617	4.75	U	4	-	-	4	4
		L	4	-	4	4	4
MIC 622	6.50	U	-	-	-	-	-
		L	-	-	4	4	4
MIC 672	5.25	U	4	4	3.5	3.5	3.5
		L	4	4	-	-	-
MIC 687	10.75	U	-	-	-	-	-
		L	-	-	-	-	4
MIC 713	11.75	U	-	-	-	-	-
		L	-	-	-	-	-
MIC 760	4.25	U	-	-	3.5	3.5	3.5
		L	-	-	4	3.5	3.5
MIC 769	10.75	U	-	-	-	-	-
		L	-	-	-	4	4
MIC 771	3.75	U	4	4	3.5	3.5	3.5
		L	4	4	3.5	-	-
MIC 773	5.50	U	-	4	-	4	4
		L	-	4	4	4	4
MIC 785	4.75	U	-	-	-	-	3.5
		L	-	-	-	-	-
MIC 853	3.50	U	4	4	3.5	3.5	3.5
		L	4	-	-	-	-
MIC 870	4.50	U	-	-	-	3.5	3.5
		L	-	-	-	-	-
MIC 924	5.50	U	-	-	-	3.5/4	3.5/4
		L	-	-	-	-	-

MIC 953	2.25	U	-	-	-	-	-
		L	-	4	3.5	-	-

*Dental Age calculated by averaging minimum and maximum age obtained from deciduous and permanent dentition

** 1 – start of mineralization / 1.5 – past start of mineralization but not yet at complete crown
2 – complete crown / 2.5 – complete crown, but not certain if eruption has occurred
3 – eruption in progress / 3.5 – eruption complete (teeth are in occlusion), but not certain if root is fully formed
4 – eruption and root complete
- could not be assessed

Table 2- Gustafson and Koch (1974) Results for Permanent Dentition

Individual	Location	1st incisor	2nd incisor	Canine	1st Premolar	2nd Premolar	1st molar	2nd Molar	3rd molar
MIC 7	U	-	-	-	-	-	-	-	-
	L	-	-	-	-	-	-	-	-
MIC 18B	U	-	-	-	-	-	2.5	1.5	-
	L	-	-	-			-	-	-
MIC 20	U	4	4	3/3.5	2/2.5	2/2.5	4	2/2.5	-
	L	4	4	-	-	-	-	2.5	-
MIC 26	U	-	-	-	-	-	-	-	-
	L	-	-	-	-	-	-	-	-
MIC 31	U	-	-	-	-	-	1.5	-	-
	L	-	-	-	-	-	-	-	-
MIC 51	U	2.5	2.5	2	1.5	-	2	-	-
	L	-	-	-	-	-	-	-	-
MIC 58	U	2	-	-	1.5	1.5	2.5	-	-
	L	-	-	-	-	-	2.5	-	-
MIC 75	U	3.5	3	-	-	-	3.5	1.5	-
	L	3.5	2	-	-	-	3.5	1.5	-
MIC 91	U	2.5	-	2.5	2.5	2.5	3/3.5	2.5	-
	L	-	-	-	-	-	2.5	-	-
MIC 111	U	-	-	-	-	-	1.5	-	-
	L	-	-	-	-	-	-	-	-
MIC 123	U	-	-	2.5	-	-	2	-	-
	L	-	-	-	-	-	-	-	-

MIC 129	U	3.5	3.5	3.5	3.5	3.5	3.5	3.5	2
	L	-	-	-	-	-	-	-	-
MIC 138	U	3	2.5	-	-	-	3.5	2	-
	L	2.5	2.5	2.5	2	2	3.5	-	-
MIC 141	U	4	3.5	-	3/3.5	3.5	3.5	2	-
	L	-	-	-	-	-	-	-	-
MIC 143	U	3.5	3.5/4	3	3.5	2	2.5	2	1
	L	-	-	-	3.5	-	-	2.5	-
MIC 178	U	-	-	-	-	-	1.5	-	-
	L	-	-	-	-	-	-	-	-
MIC 183C	U	2	2	-	-	-	2/2.5	1.5	-
	L	-	2	-	-	-	2/2.5	1.5	-
MIC 186A	U	-	-	-	-	-	1.5	-	-
	L	-	-	-	-	-	-	-	-
MIC 197	U	-	-	-	-	-	1.5	-	-
	L	-	-	-	-	-	-	-	-
MIC 205B	U	2.5	-	-	-	-	3.5	1.5	-
	L	-	-	-	-	-	-	-	-
MIC 225	U	2	-	-	-	-	2	-	-
	L	2	-	-	-	-	-	-	-
MIC 245	U	-	-	2	2/3.5	2	4	-	-
	L	-	-	-	3.5	-	-	2.5	-
MIC 251B	U	-	-	-	-	-	-	-	-
	L	-	-	-	-	-	-	-	-
MIC 253	U	-	-	-	-	-	1.5	-	-
	L	-	-	-	-	-	1.5	-	-
MIC 256	U	-	-	-	1.5	1.5	2.5	1.5	-
	L	-	-	-	-	-	2.5	-	-
MIC 258	U	2	2	1.5	-	-	2	-	-
	L	-	-	-	-	-	2	1	-
MIC 275	U	-	-	-	-	-	3.5	-	-
	L	2	2	-	-	-	3.5	-	-
MIC 319	U	3.5	3.5	2/3	3.5	2	3.5	2.5	-
	L	-	-	-	-	-	-	-	-
MIC 323	U	1.5	1	1	-	-	1.5	-	-
	L	1.5	-	-	-	-	1	-	-
MIC 331	U	-	-	2.5	2	-	3	1.5	-
	L	-	-	-	2	-	-	-	-
MIC 347	U	-	-	-	-	2	2.5	-	-
	L	-	-	-	-	-	-	-	-
MIC 389	U	4	4	3/3.5	3.5	3.5	3.5	3.5	1.5
	L	-	4	-	-	-	-	-	-

MIC 408	U	-	-	-	-	-	2	-	-
	L	2	2	1.5	-	2	-	-	-
MIC 414	U	3.5	3.5	2	3	-	3.5	2	-
	L	-	-	-	-	-	-	-	-
MIC 423	U	2	2	-	-	-	2	1.5	-
	L	2	-	-	-	-	-	-	-
MIC 433	U	-	2	-	-	-	3.5	2	-
	L	-	-	-	-	-	-	-	-
MIC 435	U	-	-	-	-	-	-	-	-
	L	-	-	-	-	-	3.5	-	-
MIC 440	U	-	-	-	-	-	-	-	-
	L	-	-	-	-	-	-	-	-
MIC 444	U	2	2	-	-	-	3.5	1.5	-
	L	-	-	-	-	-	3.5	1.5	-
MIC 467	U	-	-	-	-	-	3.5	-	-
	L	-	-	-	-	-	-	-	-
MIC 485A	U	-	-	-	-	-	-	-	-
	L	3	2	2	-	-	3.5	1.5	-
MIC 493	U	3.5	3.5	3	3.5	3.5	3.5	3	1
	L	-	-	3	3.5	3.5	3.5	3.5	1
MIC 500	U	-	-	-	-	-	1.5	-	-
	L	-	-	-	-	-	-	-	-
MIC 540	U	2/2.5	2.5	2	2	2	2	2	-
	L	3.5	-	2	2	-	3.5	2	-
MIC 542	U	-	-	-	-	-	1	-	-
	L	-	-	-	-	-	1	-	-
MIC 616	U	-	-	-	-	-	4	-	2.5
	L	-	-	-	3.5	3.5	-	-	-
MIC 617	U	2	2	2	-	-	2.5	-	-
	L	-	2.5	-	-	-	2.5	1.5	-
MIC 622	U	-	2.5	2.5	2	-	3.5	2	-
	L	3	3	2.5	2	2	3.5	2	-
MIC 672	U	2	2	-	-	-	3.5	1.5	-
	L	-	2	1.5	-	-	3.5	-	-
MIC 687	U	3.5	3.5	3	3.5	3.5	3.5/4	3.5	1.5
	L	3.5	3.5/4	3	3	-	3.5/4	3.5	-
MIC 713	U	-	-	-	4	4	-	-	1.5
	L	4	4	-	4	4	-	3.5	-
MIC 760	U	-	-	-	-	-	2	1.5	-
	L	-	-	-	-	-	2	1.5	-
MIC 769	U	3.5/4	-	2.5	-	2.5/3	3.5	3	1.5
	L	3.5	3.5/4	3	2/3	2/2.5	3.5	3.5	-

MIC 771	U	-	-	-	-	-	2	-	-
	L	-	-	-	-	-	-	-	-
MIC 773	U	2	-	-	2	-	-	1.5	-
	L	-	2	2	1.5	-	3.5	1.5	-
MIC 785	U	2	-	-	-	-	-	-	-
	L	-	-	-	-	-	-	-	-
MIC 853	U	-	-	-	-	-	1.5	-	-
	L	-	-	-	-	-	-	-	-
MIC 870	U	-	-	-	-	-	1.5	-	-
	L	-	-	-	-	-	-	-	-
MIC 924	U	2.5	2	-	-	-	2.5/3.5	2	-
	L	-	2.5	-	-	-	2.5	-	-
MIC 953	U	-	-	-	-	-	-	-	-
	L	-	-	-	-	-	1.5	-	-

Table 3 – Long Bone Lengths

Individual	Femur (mm)	Tibia (mm)	Humerus (mm)	Radius (mm)	Ulna (mm)
MIC 7	78	68	-	54	-
MIC 18B	188	146	-	-	-
MIC 20	291	-	211	164	180
MIC 26	-	-	-	51	60
MIC 31	163	129	128	92	-
MIC 51	251	-	173	128	144
MIC 58	225	172	164	-	132
MIC 75	260	213	192	138	-
MIC 91	224	173	166	127	-
MIC 111	171	144	136	105	116
MIC 123	130	104	104	76	87
MIC 129	333	273	235	172	193
MIC 138	228	-	168	-	141
MIC 141	262	213	-	149	166
MIC 143	286	221	-	-	-
MIC 178	-	106	107	-	-
MIC 183C	223	182	160	115	-
MIC 186A	173	140	-	-	-
MIC 197	146	119	113	81	92
MIC 205B	235	-	-	-	-
MIC 225	192	147	139	106	117
MIC 245	282	-	-	-	-
MIC 251B	72	61	-	-	55

MIC 253	145	115	115	-	-
MIC 256	203	160	151	108	123
MIC 258	-	-	157	-	-
MIC 275	234	-	-	-	-
MIC 319	289	229	211	157	171
MIC 323	-	-	113	-	92
MIC 331	223	180	-	121	-
MIC 347	204	160	155	114	124
MIC 389	296	-	226	165	179
MIC 408	195	159	-	104	114
MIC 414	280	220	206	154	-
MIC 423	171	-	137	104	-
MIC 433	-	-	-	146	164
MIC 435	256	203	-	138	155
MIC 440	92	-	77	-	-
MIC 444	237	196	-	132	146
MIC 467	227	182	164	-	-
MIC 485A	236	-	169	-	-
MIC 493	-	220	-	-	-
MIC 500	143	117	112	-	-
MIC 540	250	201	180	-	-
MIC 542	127	101	102	72	82
MIC 616	326	257	-	162	-
MIC 617	204	162	155	110	121
MIC 622	240	188	180	124	139
MIC 672	198	167	-	-	-
MIC 687	340	277	-	178	-
MIC 713	375	310	-	200	-
MIC 760	191	150	148	103	115
MIC 769	306	-	212	163	-
MIC 771	-	118	-	86	-
MIC 773	231	-	172	127	-
MIC 785	179	148	141	104	112
MIC 853	171	134	133	-	102
MIC 870	-	143	-	-	-
MIC 924	243	192	172	-	-
MIC 953	-	-	132	-	107

Table 4 – Age Estimates Based off of Long Bone Length (Ages Averaged)

Individual	Femur (years)	Tibia (years)	Humerus (years)	Radius (years)	Ulna (years)
MIC 7	0	0.125	-	0	-
MIC 18B	2.50	2.50	-	-	-
MIC 20	7.00	-	7.75	8.50	8.75
MIC 26	-	-	-	0	0
MIC 31	2.00	1.50	2.00	1.75	-
MIC 51	5.25	-	4.75	4.75	5.00
MIC 58	4.25	3.75	4.25	-	3.75
MIC 75	5.75	6.00	6.00	5.75	-
MIC 91	4.25	3.75	4.25	4.50	-
MIC 111	2.00	2.25	2.50	2.75	2.75
MIC 123	0.75	0.75	1.00	0.75	0.75
MIC 129	9.25	9.50	9.75	9.50	10.00
MIC 138	4.25	-	4.50	-	4.50
MIC 141	5.75	6.00	-	6.75	7.00
MIC 143	7.00	6.25	-	-	-
MIC 178	-	1.00	1.00	-	-
MIC 183C	3.75	4.00	3.75	3.50	-
MIC 186A	2.00	2.00	-	-	-
MIC 197	1.75	1.25	1.25	1.00	1.00
MIC 205B	4.50	-	-	-	-
MIC 225	2.75	2.50	2.75	2.75	2.75
MIC 245	6.50	-	-	-	-
MIC 251B	0.00	0.00	-	-	0.00
MIC 253	1.25	1.25	1.50	-	-
MIC 256	3.25	3.00	3.25	2.75	3.25
MIC 258	-	-	3.75	-	-
MIC 275	4.25	-	-	-	-
MIC 319	7.00	6.75	7.75	7.75	7.75
MIC 323	-	-	1.25	-	1.00
MIC 331	3.75	3.75	-	4.00	-
MIC 347	3.25	3.25	3.75	3.50	3.25
MIC 389	7.50	-	8.75	8.75	8.25
MIC 408	2.75	3.00	-	2.75	2.25
MIC 414	6.50	6.25	7.25	7.50	-
MIC 423	2.00	-	2.50	2.75	-
MIC 433	-	-	-	6.75	7.00
MIC 435	5.50	5.25	-	5.75	6.00

MIC 440	0.187	-	0.25	-	-
MIC 444	4.75	5.00	-	5.00	5.00
MIC 467	4.25	4.00	4.25	-	-
MIC 485A	4.75	-	4.50	-	-
MIC 493	-	6.25	-	-	-
MIC 500	1.25	1.25	1.25	-	-
MIC 540	5.25	5.00	5.25	-	-
MIC 542	0.75	0.75	1.00	0.75	0.75
MIC 616	8.75	8.25	-	8.50	-
MIC 617	3.25	3.00	3.75	3.00	2.75
MIC 622	4.75	4.25	5.25	4.50	4.50
MIC 672	3.00	3.25	-	-	-
MIC 687	9.75	9.75	-	10.00	-
MIC 713	11.25	11.25	-	11.75	-
MIC 760	2.75	2.50	3.25	2.50	2.50
MIC 769	8.00	-	7.75	8.50	-
MIC 771	-	1.25	-	1.25	-
MIC 773	4.25	-	4.75	4.50	-
MIC 785	2.25	2.50	2.75	2.75	2.25
MIC 853	2.00	2.00	2.25	-	1.50
MIC 870	-	2.00	-	-	-
MIC 924	4.75	4.75	4.75	-	-
MIC 953	-	-	2.25	-	2.00

Table 5 – Femur Appositional Growth, Medullary Width and Cortical Thickness

Skeleton	Femur Midshaft Width (mm)	Femur Medullary Width (mm)	Femur Cortical thickness (mm)
MIC 7	7.0	2.7	4.3
MIC 18B	12.7	5.8	6.9
MIC 20	16.7	9.0	7.7
MIC 26	-	-	-
MIC 31	12.5	8.3	4.2
MIC 51	17.2	10.9	6.3
MIC 58	14.0	7.6	6.4
MIC 75	18.3	8.7	9.6
MIC 91	16.3	10.0	6.3
MIC 111	13.3	7.3	6.0
MIC 123	10.2	6.2	4.0

MIC 129	20.9	7.7	13.2
MIC 138	14.7	9.9	4.8
MIC 141	16.5	7.7	8.8
MIC 143	15.7	8.7	7.0
MIC 178	-	-	-
MIC 183C	14.7	8.3	6.4
MIC 186A	12.4	7.7	4.7
MIC 197	11.6	7.4	4.2
MIC 205B	14.4	8.0	6.4
MIC 225	13.1	7.2	5.9
MIC 245	17.6	9.9	7.7
MIC 251B	5.9	1.8	4.1
MIC 253	10.6	5.6	5.0
MIC 256	13.3	8.4	4.9
MIC 258	-	-	-
MIC 275	13.3	6.6	6.7
MIC 319	17.8	6.1	11.7
MIC 323	-	-	-
MIC 331	14.2	7.1	7.1
MIC 347	12.6	6.8	5.8
MIC 389	17.1	11.7	5.4
MIC 408	15.2	8.9	6.3
MIC 414	17.6	7.4	10.2
MIC 423	13.5	9.5	4.0
MIC 433	-	-	-
MIC 435	15.0	8.9	6.1
MIC 440	8.7	3.4	5.3
MIC 444	15.7	7.5	8.2
MIC 467	12.5	6.4	6.1
MIC 485A	15.0	8.4	6.6
MIC 493	-	-	-
MIC 500	11.5	6.0	5.5
MIC 540	15.0	8.0	7.0
MIC 542	10.4	5.8	4.6
MIC 616	18.7	10.3	8.4
MIC 617	14.3	7.2	7.1
MIC 622	15.7	8.5	7.2
MIC 672	13.1	6.7	6.4
MIC 687	19.0	9.0	10.0
MIC 713	21.5	11.7	9.8
MIC 760	13.0	8.2	4.8
MIC 769	17.8	7.2	10.6

MIC 771	-	-	-
MIC 773	14.1	7.7	6.4
MIC 785	12.8	6.9	5.9
MIC 853	12.4	9.0	3.4
MIC 870	-	-	-
MIC 924	15.8	9.1	6.7
MIC 953	-	-	-

Table 6 – Tibia Appositional Growth, Medullary Width, and Cortical Thickness

Skeleton	Tibia Midshaft Width (mm)	Tibia Medullary Width (mm)	Tibia Cortical thickness (mm)
MIC 7	6.2	2.8	3.4
MIC 18B	12.9	5.8	7.1
MIC 20	-	-	-
MIC 26	-	-	-
MIC 31	12.5	9.4	3.1
MIC 51	-	-	-
MIC 58	12.5	7.1	5.4
MIC 75	15.3	9.7	5.6
MIC 91	14.0	8.2	5.8
MIC 111	13.1	7.0	6.1
MIC 123	9.5	5.1	4.4
MIC 129	18.9	12.1	6.8
MIC 138	-	-	-
MIC 141	16.3	9.4	6.9
MIC 143	15.1	9.4	5.7
MIC 178	9.1	5.1	4.0
MIC 183C	12.9	7.3	5.6
MIC 186A	11.1	6.5	4.6
MIC 197	10.6	6.8	3.8
MIC 205B	-	-	-
MIC 225	12.5	6.8	5.7
MIC 245	-	-	-
MIC 251B	5.6	1.7	3.9
MIC 253	9.3	5.4	3.9
MIC 256	12.0	6.9	5.1
MIC 258	-	-	-
MIC 275	-	-	-

MIC 319	15.0	7.8	7.2
MIC 323	-	-	-
MIC 331	12.5	6.4	6.1
MIC 347	11.0	6.2	4.8
MIC 389	-	-	-
MIC 408	13.8	7.2	6.6
MIC 414	16.4	7.7	8.7
MIC 423	-	-	-
MIC 433	-	-	-
MIC 435	13.6	8.6	5.0
MIC 440	-	-	-
MIC 444	14.0	8.4	5.6
MIC 467	13.2	8.6	4.6
MIC 485A	-	-	-
MIC 493	17.2	12.0	5.2
MIC 500	11.2	5.4	5.8
MIC 540	12.3	5.8	6.5
MIC 542	8.8	5.3	3.5
MIC 616	15.7	9.9	5.8
MIC 617	12.0	7.1	4.9
MIC 622	15.0	7.8	7.2
MIC 672	11.6	6.3	5.3
MIC 687	16.0	9.5	6.5
MIC 713	19.2	12.2	7.0
MIC 760	13.7	5.9	7.8
MIC 769	-	-	-
MIC 771	9.0	4.9	4.1
MIC 773	-	-	-
MIC 785	10.8	5.6	5.2
MIC 853	11.3	7.8	3.5
MIC 870	10.2	5.2	5.0
MIC 924	14.9	8.3	6.6
MIC 953	-	-	-

Table 7 – Humerus Appositional Growth, Medullary Width, and Cortical Thickness

Individual	Humerus Midshaft Width (mm)	Humerus Medullary Width (mm)	Humerus Cortical thickness (mm)
MIC 7	-	-	-
MIC 18B	-	-	-
MIC 20	11.5	5.9	5.6
MIC 26	-	-	-
MIC 31	10.5	7.1	3.4
MIC 51	12.1	7.9	4.2
MIC 58	9.9	5.3	4.6
MIC 75	11.6	5.5	6.1
MIC 91	11.5	5.9	5.6
MIC 111	12.0	8.2	3.8
MIC 123	9.0	5.6	3.4
MIC 129	15.0	7.4	7.6
MIC 138	10.7	7.0	3.7
MIC 141	-	-	-
MIC 143	-	-	-
MIC 178	9.9	5.8	4.1
MIC 183C	10.9	5.9	5.0
MIC 186A	-	-	-
MIC 197	8.6	5.9	2.7
MIC 205B	-	-	-
MIC 225	10.0	6.8	3.2
MIC 245	-	-	-
MIC 251B	-	-	-
MIC 253	8.6	4.6	4.0
MIC 256	11.1	6.6	4.5
MIC 258	12.5	8.0	4.5
MIC 275	-	-	-
MIC 319	13.8	7.6	6.2
MIC 323	9.9	5.9	4.0
MIC 331	-	-	-
MIC 347	10.4	6.5	3.9
MIC 389	12.6	8.4	4.2
MIC 408	-	-	-
MIC 414	13.2	4.9	8.3
MIC 423	11.4	8.6	2.8
MIC 433	-	-	-

MIC 435	-	-	-
MIC 440	7.0	3.6	3.4
MIC 444	-	-	-
MIC 467	10.6	6.4	4.2
MIC 485A	11.7	6.2	5.5
MIC 493	-	-	-
MIC 500	9.7	5.9	3.8
MIC 540	10.8	5.6	5.2
MIC 542	9.0	5.4	3.6
MIC 616	-	-	-
MIC 617	12.0	6.8	5.2
MIC 622	12.3	5.8	6.5
MIC 672	-	-	-
MIC 687	-	-	-
MIC 713	-	-	-
MIC 760	10.2	6.5	3.7
MIC 769	13.8	7.6	6.2
MIC 771	-	-	-
MIC 773	11.8	7.0	4.8
MIC 785	9.8	5.1	4.7
MIC 853	11.5	8.4	3.1
MIC 870	-	-	-
MIC 924	11.6	6.2	5.4
MIC 953	12.0	7.8	4.2

Table 8 – Radius Appositional Growth, Medullary Width and Cortical Thickness

Individual	Radius Midshaft Width (mm)	Radius Medullary Width (mm)	Radius Cortical Thickness (mm)
MIC 7	4.1	1.1	3.0
MIC 18B	-	-	-
MIC 20	7.4	2.8	4.6
MIC 26	3.5	1.3	2.2
MIC 31	8.0	4.4	3.6
MIC 51	8.1	4.2	3.9
MIC 58	-	-	-
MIC 75	9.1	4.0	5.1

MIC 91	-	-	-
MIC 111	7.3	3.7	3.6
MIC 123	5.6	2.9	2.7
MIC 129	10.3	4.3	6.0
MIC 138	-	-	-
MIC 141	9.6	3.3	6.3
MIC 143	-	-	-
MIC 178	-	-	-
MIC 183C	7.1	2.9	4.2
MIC 186A	-	-	-
MIC 197	7.0	4.4	2.6
MIC 205B	-	-	-
MIC 225	6.7	3.3	3.4
MIC 245	-	-	-
MIC 251B	-	-	-
MIC 253	-	-	-
MIC 256	9.6	4.6	5.0
MIC 258	-	-	-
MIC 275	-	-	-
MIC 319	10.2	3.9	6.3
MIC 323	-	-	-
MIC 331	8.5	3.6	4.9
MIC 347	6.6	4.3	2.3
MIC 389	8.5	5.2	3.3
MIC 408	8.8	4.7	4.1
MIC 414	10.3	2.8	7.5
MIC 423	7.9	5.3	2.6
MIC 433	10.9	6.5	4.4
MIC 435	9.0	5.2	3.8
MIC 440	-	-	-
MIC 444	8.2	3.3	4.9
MIC 467	-	-	-
MIC 485A	-	-	-
MIC 493	-	-	-
MIC 500	-	-	-
MIC 540	-	-	-
MIC 542	6.5	4.2	2.3
MIC 616	9.2	4.3	4.9
MIC 617	8.8	4.9	3.9
MIC 622	9.2	3.4	5.8
MIC 672	-	-	-
MIC 687	10.8	4.6	6.2

MIC 713	10.9	5.1	5.8
MIC 760	7.5	4.3	3.2
MIC 769	11.0	5.9	5.1
MIC 771	-	-	-
MIC 773	8.9	4.5	4.4
MIC 785	6.2	2.4	3.8
MIC 853	-	-	-
MIC 870	-	-	-
MIC 924	-	-	-
MIC 953	-	-	-

Table 9 – Ulna Appositional Growth, Medullary Width and Cortical Thickness

Individual	Ulna Midshaft Width (mm)	Ulna Medullary Width (mm)	Ulna Cortical thickness (mm)
MIC 7	-	-	-
MIC 18B	-	-	-
MIC 20	8.2	4.0	4.2
MIC 26	3.8	1.3	2.5
MIC 31	-	-	-
MIC 51	-	-	-
MIC 58	6.6	2.9	3.7
MIC 75	-	-	-
MIC 91	-	-	-
MIC 111	6.5	3.1	3.4
MIC 123	5.4	1.8	3.6
MIC 129	9.8	3.5	6.3
MIC 138	6.6	3.4	3.2
MIC 141	8.1	3.8	4.3
MIC 143	-	-	-
MIC 178	-	-	-
MIC 183C	-	-	-
MIC 186A	-	-	-
MIC 197	5.5	2.4	3.1
MIC 205B	-	-	-
MIC 225	6.7	2.6	4.1
MIC 245	-	-	-
MIC 251B	3.1	1.2	1.9
MIC 253	-	-	-

MIC 256	6.6	2.7	3.9
MIC 258	-	-	-
MIC 275	-	-	-
MIC 319	8.8	3.8	5.0
MIC 323	5.7	2.9	2.8
MIC 331	-	-	-
MIC 347	6.0	3.1	2.9
MIC 389	7.5	4.2	3.3
MIC 408	7.4	3.3	4.1
MIC 414	-	-	-
MIC 423	-	-	-
MIC 433	10.3	5.7	4.6
MIC 435	7.5	3.7	3.8
MIC 440	-	-	-
MIC 444	7.5	2.9	4.6
MIC 467	-	-	-
MIC 485A	-	-	-
MIC 493	-	-	-
MIC 500	-	-	-
MIC 540	-	-	-
MIC 542	-	-	-
MIC 616	-	-	-
MIC 617	7.9	3.8	4.1
MIC 622	7.6	3.3	4.3
MIC 672	-	-	-
MIC 687	-	-	-
MIC 713	-	-	-
MIC 760	5.7	3.0	2.7
MIC 769	-	-	-
MIC 771	-	-	-
MIC 773	-	-	-
MIC 785	7.4	3.4	4.0
MIC 853	6.4	3.8	2.6
MIC 870	-	-	-
MIC 924	-	-	-
MIC 953	7.6	5.0	2.6

Table 10 – Body Mass Estimations and Measurements

Individual	Dental Age (years)	Femoral Distal Metaphysis (mm)	Femoral Head Breadth (mm)	Body mass estimation (Kg)
MIC 7	0	-	-	-
MIC 18B	5.00	-	-	-
MIC 20	8.50	-	31.3	26.36
MIC 26	0	-	-	-
MIC 31	4.00	41.5	-	12.91
MIC 51	6.00	50.2	-	18.02
MIC 58	5.25	48.9	-	16.35
MIC 75	7.50	-	-	-
MIC 91	6.50	49.5	-	18.46
MIC 111	2.50	-	-	-
MIC 123	1.50	34.7	-	9.31
MIC 129	11.75	-	34.4	32.34
MIC 138	6.50	45.6	-	16.92
MIC 141	9.50	-	28.4	24.11
MIC 143	10.00	-	29.4	25.40
MIC 178	1.50	-	-	-
MIC 183C	4.75	-	-	-
MIC 186A	2.00	40.2	-	10.97
MIC 197	2.00	36.2	-	9.90
MIC 205B	5.50	-	-	-
MIC 225	4.50	-	-	-
MIC 234	3.5*	45.2	-	13.62
MIC 245	9.50	-	28.3	23.99
MIC 251B	0	-	-	-
MIC 253	2.25	-	-	-
MIC 256	4.50	42.6	-	13.65
MIC 258	4.50	-	-	-
MIC 275	5.25	-	-	-
MIC 319	11.50	-	31.5	27.60
MIC 323	1.75	38.7	-	10.57
MIC 331	6.50	44.2	-	16.37
MIC 347	4.75	46.1	-	15.32
MIC 389	11.50	-	28.8	22.91
MIC 408	4.25	45.5	-	14.22
MIC 414	6.50	-	-	-
MIC 423	4.25	-	-	-

MIC 433	6.50	-	-	-
MIC 435	8.00	-	-	-
MIC 440	0.25	-	-	-
MIC 444	5.25	52.1	-	17.52
MIC 467	7.00	-	-	-
MIC 485A	6.50	-	-	-
MIC 493	9.50	-	-	-
MIC 500	2.25	-	-	-
MIC 540	5.50	41.9	-	14.38
MIC 542	1.25	-	-	-
MIC 616	11.50	-	31.3	27.25
MIC 617	4.75	49.3	-	16.49
MIC 622	6.50	46.3	-	17.19
MIC 672	5.25	44.0	-	14.55
MIC 687	10.75	-	33.1	30.82
MIC 713	11.75	-	34.8	33.08
MIC 760	4.25	46.7	-	14.62
MIC 769	10.75	-	31.9	28.87
MIC 771	3.75	-	-	-
MIC 773	5.50	-	-	-
MIC 785	4.75	36.2	-	11.69
MIC 853	3.50	-	-	-
MIC 870	4.50	-	-	-
MIC 924	5.50	51.0	-	17.72
MIC 953	2.25	-	-	-

* Age-at-death for MIC 234 based off of timing of epiphyseal fusion

Table 11 – Subadult Burial Date, Grave Goods and Burial Type (obtained from Paillard 2006)

Individual	Period	Grave goods	Burial type
MIC 7	Roman	None	Wooden coffin
MIC 18B	Roman	None	Fill
MIC 20	Merovingian	None	Wooden coffin
MIC 26	Merovingian	None	Earth cut
MIC 31	Roman	None	Earth cut
MIC 51	Merovingian	None	Earth cut
MIC 58	Merovingian	None	Wooden coffin
MIC 75	Merovingian	None	Wooden coffin
MIC 91	Merovingian	None	Wedging stones and wooden component

MIC 111	Roman	None	Wooden coffin
MIC 123	Roman	Grave goods present	Earth cut
MIC 129	Roman	None	Wedging stones
MIC 138	Merovingian	None	Earth cut
MIC 141	Roman	None	Wooden coffin
MID 143	Roman	None	Wooden coffin
MIC 178	Roman	None	Wooden coffin
MIC 183C	Merovingian	None	Earth cut
MIC 186A	Merovingian	None	Wedging stones
MIC 197	Roman	None	Wooden coffin
MIC 205B	Merovingian	None	Fill
MIC 225	Merovingian	None	Wedging stones and wooden component
MIC 245	Merovingian	None	Earth cut
MIC 251B	Merovingian	None	Earth cut
MIC 253	Merovingian	None	Wedging stones
MIC 256	Merovingian	None	Wooden coffin
MIC 258	Merovingian	None	Earth cut
MIC 275	Merovingian	None	Wooden coffin
MIC 319	Roman	Grave goods present	Wooden coffin
MIC 323	Roman	Grave goods present	Sarcophagus
MIC 331	Roman	None	Wooden coffin
MIC 347	Roman	Grave goods present	Wooden coffin
MIC 389	Roman	None	Wooden coffin
MIC 408	Roman	Grave goods present	Wedging stones and wooden component
MIC 414	Roman	None	Wooden coffin
MIC 423	Roman	None	Wooden coffin
MIC 433	Roman	None	Earth cut
MIC 435	Roman	Grave goods present	Wedging stones and wooden component
MIC 440	Roman	None	Wooden coffin
MIC 444	Roman	None	Wooden coffin
MIC 467	Roman	None	Wooden coffin

MIC 485A	Roman	None	Earth cut
MIC 493	Roman	Grave goods present	Wedging stones and wooden component
MIC 500	Merovingian	None	Wedging stones and wooden component
MIC 540	Roman	None	Wooden coffin
MIC 542	Roman	None	Wooden coffin
MIC 616	Roman	None	Wooden coffin
MIC 617	Roman	None	Wooden coffin
MIC 622	Roman	None	Wooden coffin
MIC 672	Roman	None	Earth cut
MIC 687	Roman	None	Earth cut
MIC 713	Roman	None	Wooden coffin
MIC 760	Roman	Grave goods present	Wooden coffin
MIC 769	Roman	None	Wooden coffin
MIC 771	Roman	None	Wooden coffin
MIC 773	Roman	None	Wooden coffin
MIC 785	Roman	None	Wooden coffin
MIC 853	Roman	None	Wooden coffin
MIC 870	Roman	None	Wooden coffin
MIC 924	Roman	None	Wooden coffin
MIC 953	Roman	None	Wedging stones

Appendix B – Pathology Forms for Rachitic Individuals

Sex/Age Estimation Date: 29-May-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 31

Age Estimation – Juvenile

Dental Development (following Gustafson and Koch 1974)

Deciduous Dentition

Maxilla				
	Left	**Right**	**Unsided 1**	**Unsided 2**
m^2	3.5	3.5	-	-
m^1	3.5	3.5	-	-
c	3.5	3.5	-	-
i^2	4	4	-	-
i^1	4	4	-	-

Mandible				
	Left	**Right**	**Unsided 1**	**Unsided 2**
m_2	-	-	-	-
m_1	-	-	-	-
c	-	-	-	-
i_2	-	-	-	-
i_1	-	-	-	-

Permanent Dentition

Maxilla				
	Left	**Right**	**Unsided 1**	**Unsided 2**
M^2	-	-	-	-
M^1	1.5	1.5	-	-
PM^2	-	-	-	-
PM^1	-	-	-	-
C	-	-	-	-
I^2	-	-	-	-
I^1	-	-	-	-

Mandible				
	Left	**Right**	**Unsided 1**	**Unsided 2**
M^2	-	-	-	-
M^1	-	-	-	-
PM^2	-	-	-	-
PM^1	-	-	-	-
C	-	-	-	-
I^2	-	-	-	-
I^1	-	-	-	-

Scoring: - = could not be assessed; 1 = start of mineralization; 1.5 = past start of mineralization, but not yet at complete crown; 2 = complete crown; 2.5 = crown complete, but not certain if eruption has occurred; 3 = eruption in progress; 3.5 eruption complete (teeth are in occlusion), but not certain if root is fully formed; 4 = eruption and root complete

If M3s are present, record side & development here: Max ____ Max ____ Mand ____ Mand _____

Long Bone Length (in mm)

	Left	**Right**
Femur	164	163
Tibia	129	129
Fibula		
Humerus	128	129
Radius	92	91
Ulna		

Notes:

Epiphyseal Fusion (following Cardoso 2008 a, b) - Fusion should be scored on **left** bone only. If left is not present right should be scored.

Femur: 1 - proximal epiphysis; 2 – greater trochanter; 3 – lesser trochanter; 4 – distal epiphysis
Tibia: 1 – proximal epiphysis; 2 – distal epiphysis
Humerus: 1 – proximal epiphysis; 2 – distal epiphysis; 3 – medial epicondyle
Radius: 1 – proximal epiphysis; 2 – distal epiphysis
Pelvis: 1 – iliac crest; 2 – ischial epiphysis
Clavicle: 1 – sternal epiphysis

	Side	**Epiphysis 1**	**Epiphysis 2**	**Epiphysis 3**	**Epiphysis 4**
Femur	left	1	1	1	1
Tibia	left	1	1		
Humerus	left	1	1	1	
Radius	left	1	1		
Pelvis	left	1	1		
Clavicle	left	1			
Other	-	-	-	-	-

Scoring: - = could not be assessed; 1 = non-union (epiphysis and diaphysis are completely separate); 2 = partial union; 3 – complete union (all visible aspects of epiphysis are united)

Sex/Age Estimation Date: 29-May-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 31

Summary Information

Dental Dev. Age Estimate	Long Bone Length Age Estimate	Epiphyseal Fusion Age Estimate	Dental Wear Age Estimate (if applicable)
2.5-3.5 years	1.5-2 years	3-4 years old.	

Notes: All vertebral arches fused, most bodies not fused, except one lumbar body with fusion lines still present. Metopic suture fused. Pars lateralis fused to squama, but not to basilaris. Epiphyseal fusion age approximately 3-4 years old.

Dental Wear (modified from Brothwell 1965) – for older adolescents and adults (M1 must be erupted and in occlusion)

Maxilla		
	Left	**Right**
M3	-	-
M2	-	-
M1	-	-

Mandible		
	Left	**Right**
M3	-	-
M2	-	-
M1	-	-

Modified scoring: - = could not be assessed; score - 1-13 (refer to diagram)

Notes:

Sex/Age Estimation Date: 29-May-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 31

Sex Estimation – Adult

Will not be attempted for those <16 years old. For those 16+ years the features of the skull/mandible and pelvis set out in Buikstra and Ubelaker (1994) will be used.

Pelvis	Left	Right
Ventral Arc (1-3) *	-	-
Subpubic Concavity (1-3) *	-	-
Ischiopubic Ramus Ridge (1-3) *	-	-
Greater Sciatic Notch (1-5) *	-	-
Preauricular Sulcus (1-4) *	-	-
Estimated Sex	Undeterminec	

Skull	Left	Right
Nuchal Crest (1-5) *	-	
Mastoid Process (1-5) *	-	-
Supraorbital Margin (1-5) *	-	-
Glabella (1-5) *	-	
Mental Eminence (1-5) *	-	
Estimated Sex	Undeterminec	

Notes:

In all cases (skull and pelvis) the left should be preferentially scored. When the left side is absent, the right can be scored.
* after observations described in Buikstra & Ubelaker 1994 (pp. 16-21):
0-3 scale: - (blank) = not observable; 1 = female; 2 = ambiguous; 3 = male
0-4 scale: - (blank) = no sulcus; 1 = sulcus is wide (>0.5cm) and deep; 2 = sulcus is wide but shallow; 3 = sulcus is well defined but narrow; 4 = sulcus is a narrow (<0.5cm), shallow, and smooth-walled depression.
0-5 scale: - (blank) = not observable; 1 = female; 2 = probable female; 3 = ambiguous; 4 = probable male; 5 = male

Age Estimation - Adult

Pubic Symphysis Scoring System (following Brooks and Suchey 1990; Suchey and Katz 1986)

	Left	Right
Phase	-	-

Notes:

Scoring: - = could not be assessed; phases 1-6 (see Buikstra and Ubelaker, 1994: 23-24)

Sex/Age Estimation Date: 29-May-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 31

Auricular Surface Scoring System – Transition Analysis (following Boldsen et al. 2002:101-103) (can record multiple stages for a single feature)[1]

	Left		Right	
	Min	Max	Min	Max
Superior Topography (1-3)	-	-	-	-
Inferior Topography (1-3)	-	-	-	-
Superior Characteristics (1-5)	-	-	-	-
Apical Characteristics (1-5)	-	-	-	-
Inferior Characteristics (1-5)	-	-	-	-
Inferior Texture (1-3)	-	-	-	-
Superior* Exostoses (1-6)	-	-	-	-
Inferior* Exostoses (1-6)	-	-	-	-
Posterior Exostoses (1-3)	-	-	-	-

Notes:

[1]Record the left auricular surface. When the left is absent, the right can be recorded but do not mix the two sides.
Scoring: - = could not be assessed; see Boldsen et al. 2002
* Superior and Inferior Posterior Iliac Crest

Summary Information – Adult Age and Sex

Age[1]	2.5-3.5 years
Sex[2]	

[1]Young adult (20-34), middle adult (35-49), old adult (50+)
[2]After Buikstra and Ubelaker (1994: 21): undetermined; female; probable female; ambiguous; probable male; male

Date: 29-May-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 31

Juvenile Pathology Form

Cranium

	Left			Right		
	Present/ Absent	Abnormal Porosity	Abnormal Shape	Present/ Absent	Abnormal Porosity	Abnormal Shape
Frontal	present	absent	absent	present	absent	absent
Orbital roof	absent	-	-	present	absent	absent
Parietal	present	absent	absent	present	absent	absent
Temporal	present	absent	absent	present	absent	absent
Maxilla	present		absent	present		absent
Mandibular ramus	absent		-	absent		-
Other	-	-	-	-	-	-

	Unsided		
Occipital	present	absent	absent

Photo

Notes:

Scoring: - = feature not observable; 0 = feature absent; 1 = feature present

Ribs

	# Left (1-12)	# Right (1-12)	# Unsided (1-24)	Abnormal Porosity[1]	Flaring[1]	Fractures[2]	Cupping[3]
Proximal Ends	10	8					
Costochondral Ends			12	-	-	-	-
Abnormal rib curvature*	-	-					

Notes:

* can only be assessed on complete ribs
[1] - Only assessed at costochondral ends.
[2] – If fracture is located somewhere other than costochondral end, indicate location and side (if possible in notes section.
[3] – indicates the total number of ribs exhibiting cupping
Scoring: - = not observable; indicate number of ribs with pathology

Photo

Date: 29-May-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 31

Long Bones – Presence[1]

Element	LEFT					RIGHT				
	Prox epip	**Prox 1/3**	**Mid 1/3**	**Distal 1/3**	**Distal epip**	**Prox epip**	**Prox 1/3**	**Mid 1/3**	**Distal 1/3**	**Distal epip**
Clavicle	<25%	>75%	>75%	>75%	>75%	-	-	-	-	-
Humerus	>75%	>75%	>75%	>75%	50-75%	25-50%	>75%	>75%	>75%	<25%
Radius	<25%	>75%	>75%	>75%	50-75%	>75%	>75%	>75%	>75%	25-50%
Ulna	<25%	50-75%	>75%	>75%	-	-	>75%	>75%	25-50%	-
Femur	50-75%	>75%	>75%	>75%	50-75%	>75%	>75%	>75%	>75%	>75%
Tibia	>75%	>75%	>75%	>75%	<25%	>75%	>75%	>75%	>75%	<25%
Fibula	-	<25%	>75%	50-75%	-	-	>75%	>75%	>75%	<25%

* segment preservation: - = not present; <25%; 25-50%; 50-75% >75%

Long Bones – Pathology

	Abnormal Growth Plate	Thickening	Abnormal Shaft Shape	Abnormal Metaphysis Shape	Other (features such as fracture)*
LEFT Side					
Clavicle		absent	absent	absent	absent
Humerus	normal	absent	absent	absent	absent
Radius	normal	absent	absent	absent	absent
Ulna	-	absent	absent	absent	absent
Femur	1	absent	absent	absent	absent
Tibia	-	absent	absent	absent	absent
Fibula	-	absent	absent	absent	absent

Notes: Slight velvet texture on distal growth plate of femur. There is a difference in texture between the proximal and distal growth plate. The growth plate of the tibia and ulna are too fragmentary to asses.

*Provide details about ‘other’ pathological features in the notes box.

** Indicate which bones/elements photographed in notes box.

[1] n/a is to be used when the growth plate is fused. Only the distal growth plate is scored. Scoring adopted from Mays et al. 2006.

Photo** ☒

Date: 29-May-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 31

Long Bones (continued)

	Abnormal Growth Plate[1]	Thickening	Abnormal Shaft Shape	Abnormal Metaphysis Shape	Other (features such as fracture)*
RIGHT Side					
Clavicle		-	-	-	-
Humerus	-	absent	absent	absent	absent
Radius	-	absent	absent	absent	absent
Ulna	-	absent	absent	absent	absent
Femur	2	absent	absent	absent	absent
Tibia	1	absent	absent	absent	absent
Fibula	-	absent	absent	absent	absent

Notes: Distal growth plate of humerus and radius too eroded to assess. Distal growth plate of femur porous and velvety. Fibula growth plate is porous, more likely to be caused by taphonomy.

*Provide details about 'other' pathological features in the notes box.
** Indicate which bones/elements photographed in notes box.
[1] n/a is to be used when the growth plate is fused. Only the distal growth plate is scored. Scoring adopted from Mays et al. 2006.

Photo** ☒

Ilium (following Ortner and Brown 2011)

	Presence (%)	Abnormal Shape
Right ilium	>75%	absent
Left ilium	>75%	absent

Notes:

- = not present; <25%; 25-50%; 50-75% >75%

Photo ☐

Sacrum (only record if sufficiently complete to assess normal curvature)

	Presence (%)	Abnormal Shape
Sacrum	<25%	-

Notes:

Photo ☐

X-rays required (y/n) (indicate in notes which bones/elements to be radiographed)	☐
X-rays completed (y/n)	☐

Summary

Possible Vitamin D deficiency present?	Yes

Sex/Age Estimation Date: 09-June-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 54

Age Estimation – Juvenile

Dental Development (following Gustafson and Koch 1974)

Deciduous Dentition

Maxilla	Left	Right	Unsided 1	Unsided 2
m^2	-	-	-	-
m^1	-	-	-	-
c	-	-	-	-
i^2	-	-	-	-
i^1	-	-	-	-

Mandible	Left	Right	Unsided 1	Unsided 2
m_2	-	-	-	-
m_1	-	-	-	-
c	-	-	-	-
i_2	-	-	-	-
i_1	-	-	-	-

Permanent Dentition

Maxilla	Left	Right	Unsided 1	Unsided 2
M^2	-	-	-	-
M^1	-	-	-	-
PM^2	-	-	-	-
PM^1	-	-	-	-
C	-	-	-	-
I^2	-	-	-	-
I^1	-	-	-	-

Mandible	Left	Right	Unsided 1	Unsided 2
M^2	-	-	1.5	-
M^1	-	-	3.5	-
PM^2	-	-	-	-
PM^1	-	-	-	-
C	-	-	-	-
I^2	-	-	-	-
I^1	-	-	-	-

Scoring: - = could not be assessed; 1 = start of mineralization; 1.5 = past start of mineralization, but not yet at complete crown; 2 = complete crown; 2.5 = crown complete, but not certain if eruption has occurred; 3 = eruption in progress; 3.5 eruption complete (teeth are in occlusion), but not certain if root is fully formed; 4 = eruption and root complete

If M3s are present, record side & development here: Max ____ Max ____ Mand ____ Mand _____

Long Bone Length
(in mm)

	Left	Right
Femur	229	227
Tibia	189	
Fibula		
Humerus	173	
Radius		
Ulna		

Notes: Two loose teeth and a partial mandible fragment. No other cranial remains.

Epiphyseal Fusion (following Cardoso 2008 a, b) - Fusion should be scored on **left** bone only. If left is not present right should be scored.

Femur: 1 - proximal epiphysis; 2 – greater trochanter; 3 – lesser trochanter; 4 – distal epiphysis
Tibia: 1 – proximal epiphysis; 2 – distal epiphysis
Humerus: 1 – proximal epiphysis; 2 – distal epiphysis; 3 – medial epicondyle
Radius: 1 – proximal epiphysis; 2 – distal epiphysis
Pelvis: 1 – iliac crest; 2 – ischial epiphysis
Clavicle: 1 – sternal epiphysis

	Side	Epiphysis 1	Epiphysis 2	Epiphysis 3	Epiphysis 4
Femur	left	1	1	1	1
Tibia	left	1	1		
Humerus	left	1	1	1	
Radius	right	1	-		
Pelvis	left	1	1		
Clavicle	left	1			
Other	-	-	-	-	-

Scoring: - = could not be assessed; 1 = non-union (epiphysis and diaphysis are completely separate); 2 = partial union; 3 – complete union (all visible aspects of epiphysis are united)

Sex/Age Estimation Date: 09-June-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 54

Summary Information

Dental Dev. Age Estimate	Long Bone Length Age Estimate	Epiphyseal Fusion Age Estimate	Dental Wear Age Estimate (if applicable)
5-6 years	4-5 years	3-5 years	

Notes: All arches of vertebrae fused, some thoracic in the process of fusing. Pars basilaris and lateralis have not fused. Appears like dens was in process of fusing to centrum and arches. (around 4 years old). No apex on dens.

Dental Wear (modified from Brothwell 1965) – for older adolescents and adults (M1 must be erupted and in occlusion)

Maxilla		
	Left	**Right**
M3	-	-
M2	-	-
M1	-	-

Mandible		
	Left	**Right**
M3	-	-
M2	-	-
M1	2	-

Modified scoring: - = could not be assessed; score - 1-13 (refer to diagram)

Notes:

Sex/Age Estimation Date: 09-June-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 54

Sex Estimation – Adult

Will not be attempted for those <16 years old. For those 16+ years the features of the skull/mandible and pelvis set out in Buikstra and Ubelaker (1994) will be used.

Pelvis		
	Left	**Right**
Ventral Arc (1-3) *	-	-
Subpubic Concavity (1-3) *	-	-
Ischiopubic Ramus Ridge (1-3) *	-	-
Greater Sciatic Notch (1-5) *	-	-
Preauricular Sulcus (1-4) *	-	-
Estimated Sex	Undetermined	

Skull		
	Left	**Right**
Nuchal Crest (1-5) *	-	
Mastoid Process (1-5) *	-	-
Supraorbital Margin (1-5) *	-	-
Glabella (1-5) *	-	
Mental Eminence (1-5) *	-	
Estimated Sex	Undetermined	

Notes:

In all cases (skull and pelvis) the left should be preferentially scored. When the left side is absent, the right can be scored.
* after observations described in Buikstra & Ubelaker 1994 (pp. 16-21):
0-3 scale: - (blank) = not observable; 1 = female; 2 = ambiguous; 3 = male
0-4 scale: - (blank) = no sulcus; 1 = sulcus is wide (>0.5cm) and deep; 2 = sulcus is wide but shallow; 3 = sulcus is well defined but narrow; 4 = sulcus is a narrow (<0.5cm), shallow, and smooth-walled depression.
0-5 scale: - (blank) = not observable; 1 = female; 2 = probable female; 3 = ambiguous; 4 = probable male; 5 = male

Age Estimation - Adult

Pubic Symphysis Scoring System (following Brooks and Suchey 1990; Suchey and Katz 1986)

	Left	**Right**
Phase	-	-

Notes:

Scoring: - = could not be assessed; phases 1-6 (see Buikstra and Ubelaker, 1994: 23-24)

Sex/Age Estimation Date: 09-June-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 54

Auricular Surface Scoring System – Transition Analysis (following Boldsen et al. 2002:101-103) (can record multiple stages for a single feature)[1]

	Left		Right	
	Min	Max	Min	Max
Superior Topography (1-3)	-	-	-	-
Inferior Topography (1-3)	-	-	-	-
Superior Characteristics (1-5)	-	-	-	-
Apical Characteristics (1-5)	-	-	-	-
Inferior Characteristics (1-5)	-	-	-	-
Inferior Texture (1-3)	-	-	-	-
Superior* Exostoses (1-6)	-	-	-	-
Inferior* Exostoses (1-6)	-	-	-	-
Posterior Exostoses (1-3)	-	-	-	-

Notes:

[1]Record the left auricular surface. When the left is absent, the right can be recorded but do not mix the two sides.
Scoring: - = could not be assessed; see Boldsen et al. 2002
* Superior and Inferior Posterior Iliac Crest

Summary Information – Adult Age and Sex

Age[1]	5-6 years
Sex[2]	

[1]Young adult (20-34), middle adult (35-49), old adult (50+)
[2]After Buikstra and Ubelaker (1994: 21): undetermined; female; probable female; ambiguous; probable male; male

Date: 09-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 54

Juvenile Pathology Form

Cranium

	Left			Right		
	Present/ Absent	Abnormal Porosity	Abnormal Shape	Present/ Absent	Abnormal Porosity	Abnormal Shape
Frontal	absent	-	-	absent	-	-
Orbital roof	absent	-	-	absent	-	-
Parietal	absent	-	-	absent	-	-
Temporal	absent	-	-	absent	-	-
Maxilla	absent		-	absent		-
Mandibular ramus	absent		-	absent		-
Other	-	-	-	-	-	-

	Unsided		
Occipital	absent	-	-

Photo

Notes:

Scoring: - = feature not observable; 0 = feature absent; 1 = feature present

Ribs

	# Left (1-12)	# Right (1-12)	# Unsided (1-24)	Abnormal Porosity[1]	Flaring[1]	Fractures[2]	Cupping[3]
Proximal Ends	2	2					
Costochondral Ends			4	-	-	-	-
Abnormal rib curvature*	-	-					

Notes:

* can only be assessed on complete ribs
[1] - Only assessed at costochondral ends.
[2] – If fracture is located somewhere other than costochondral end, indicate location and side (if possible in notes section.
[3] – indicates the total number of ribs exhibiting cupping
Scoring: - = not observable; indicate number of ribs with pathology

Photo

Date: 09-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 54

Long Bones – Presence[1]

Element	LEFT					RIGHT				
	Prox epip	Prox 1/3	Mid 1/3	Distal 1/3	Distal epip	Prox epip	Prox 1/3	Mid 1/3	Distal 1/3	Distal epip
Clavicle	>75%	<25%	-	-	-	-	-	-	-	-
Humerus	<25%	>75%	>75%	>75%	>75%	-	-	-	-	-
Radius	-	<25%	>75%	>75%	<25%	>75%	>75%	>75%	50-75%	<25%
Ulna	>75%	>75%	>75%	<25%	-	>75%	>75%	>75%	<25%	-
Femur	>75%	>75%	>75%	>75%	25-50%	50-75%	>75%	>75%	>75%	<25%
Tibia	<25%	>75%	>75%	>75%	<25%	50-75%	>75%	>75%	<25%	-
Fibula	-	-	25-50%	-	-	-	-	25-50%	-	-

* segment preservation: - = not present; <25%; 25-50%; 50-75% >75%

Long Bones – Pathology

	Abnormal Growth Plate	Thickening	Abnormal Shaft Shape	Abnormal Metaphysis Shape	Other (features such as fracture)*
LEFT Side					
Clavicle		-	-	-	-
Humerus	normal	absent	absent	absent	absent
Radius	normal	absent	absent	absent	absent
Ulna	-	absent	absent	absent	absent
Femur	normal	absent	present	absent	absent
Tibia	normal	absent	absent	absent	absent
Fibula	-	-	-	-	-

Notes: Possible medial bowing of the midshaft diaphysis of the femur.

*Provide details about 'other' pathological features in the notes box.

** Indicate which bones/elements photographed in notes box.

[1] n/a is to be used when the growth plate is fused. Only the distal growth plate is scored. Scoring adopted from Mays et al. 2006.

Photo**

Date: 09-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 54

Long Bones (continued)

	Abnormal Growth Plate[1]	Thickening	Abnormal Shaft Shape	Abnormal Metaphysis Shape	Other (features such as fracture)*
RIGHT Side					
Clavicle		-	-	-	-
Humerus	-	-	-	-	-
Radius	normal	absent	absent	absent	absent
Ulna	-	absent	absent	absent	absent
Femur	normal	absent	present	absent	absent
Tibia	-	absent	absent	absent	absent
Fibula	-	-	-	-	-
Notes: Possible medial bowing of the midshaft diaphysis of the femur					

*Provide details about 'other' pathological features in the notes box.
** Indicate which bones/elements photographed in notes box.
[1] n/a is to be used when the growth plate is fused. Only the distal growth plate is scored. Scoring adopted from Mays et al. 2006.

Photo** ☒

Ilium (following Ortner and Brown 2011)

	Presence (%)	Abnormal Shape
Right ilium	>75%	absent
Left ilium	>75%	absent

Notes:

Photo ☐

- = not present; <25%; 25-50%; 50-75% >75%

Sacrum (only record if sufficiently complete to assess normal curvature)

	Presence (%)	Abnormal Shape
Sacrum	-	-

Notes:

Photo ☐

X-rays required (y/n) (indicate in notes which bones/elements to be radiographed)	☐
X-rays completed (y/n)	☐

Summary

Possible Vitamin D deficiency present?	Yes

Sex/Age Estimation Date: 26-May-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 95

Age Estimation – Juvenile

Dental Development (following Gustafson and Koch 1974)

Deciduous Dentition

Maxilla	Left	Right	Unsided 1	Unsided 2
m^2	-	-	-	-
m^1	-	-	-	-
c	-	-	-	-
i^2	-	-	-	-
i^1	-	-	-	-

Mandible	Left	Right	Unsided 1	Unsided 2
m_2	-	-	-	-
m_1	-	-	-	-
c	-	-	-	-
i_2	-	-	-	-
i_1	-	-	-	-

Permanent Dentition

Maxilla	Left	Right	Unsided 1	Unsided 2
M^2	-	-	-	-
M^1	-	-	-	-
PM^2	-	-	-	-
PM^1	-	-	-	-
C	-	-	-	-
I^2	-	-	-	-
I^1	-	-	-	-

Mandible	Left	Right	Unsided 1	Unsided 2
M^2	-	-	-	-
M^1	-	-	-	-
PM^2	-	-	-	-
PM^1	-	-	-	-
C	-	-	-	-
I^2	-	-	-	-
I^1	-	-	-	-

Scoring: - = could not be assessed; 1 = start of mineralization; 1.5 = past start of mineralization, but not yet at complete crown; 2 = complete crown; 2.5 = crown complete, but not certain if eruption has occurred; 3 = eruption in progress; 3.5 eruption complete (teeth are in occlusion), but not certain if root is fully formed; 4 = eruption and root complete

If M3s are present, record side & development here: Max ____ Max ____ Mand ____ Mand _____

Long Bone Length (in mm)

	Left	Right
Femur	106	
Tibia	91	91
Fibula		
Humerus		86
Radius		68
Ulna		

Notes: No dentition

Epiphyseal Fusion (following Cardoso 2008 a, b) - Fusion should be scored on **left** bone only. If left is not present right should be scored.

Femur: 1 - proximal epiphysis; 2 – greater trochanter; 3 – lesser trochanter; 4 – distal epiphysis
Tibia: 1 – proximal epiphysis; 2 – distal epiphysis
Humerus: 1 – proximal epiphysis; 2 – distal epiphysis; 3 – medial epicondyle
Radius: 1 – proximal epiphysis; 2 – distal epiphysis
Pelvis: 1 – iliac crest; 2 – ischial epiphysis
Clavicle: 1 – sternal epiphysis

	Side	Epiphysis 1	Epiphysis 2	Epiphysis 3	Epiphysis 4
Femur	left	1	1	1	1
Tibia	left	1	1		
Humerus	right	1	1	1	
Radius	right	1	1		
Pelvis	left	1	1		
Clavicle	left	1			
Other	-	-	-	-	-

Scoring: - = could not be assessed; 1 = non-union (epiphysis and diaphysis are completely separate); 2 = partial union; 3 – complete union (all visible aspects of epiphysis are united)

Sex/Age Estimation Date: 26-May-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 95

Summary Information

Dental Dev. Age Estimate	Long Bone Length Age Estimate	Epiphyseal Fusion Age Estimate	Dental Wear Age Estimate (if applicable)
No dentition	6mos	Less than 1 year	
Notes: No vertebral arches or centrum have fused. Thus less than 1 year.			

Dental Wear (modified from Brothwell 1965) – for older adolescents and adults (M1 must be erupted and in occlusion)

Maxilla		
	Left	**Right**
M3	-	-
M2	-	-
M1	-	-

Mandible		
	Left	**Right**
M3	-	-
M2	-	-
M1	-	-

Modified scoring: - = could not be assessed; score - 1-13 (refer to diagram)

Notes:

Sex/Age Estimation Date: 26-May-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 95

Sex Estimation – Adult

Will not be attempted for those <16 years old. For those 16+ years the features of the skull/mandible and pelvis set out in Buikstra and Ubelaker (1994) will be used.

Pelvis	Left	Right
Ventral Arc (1-3) *	-	-
Subpubic Concavity (1-3) *	-	-
Ischiopubic Ramus Ridge (1-3) *	-	-
Greater Sciatic Notch (1-5) *	-	-
Preauricular Sulcus (1-4) *	-	-
Estimated Sex	Undetermined	

Skull	Left	Right
Nuchal Crest (1-5) *	-	
Mastoid Process (1-5) *	-	-
Supraorbital Margin (1-5) *	-	-
Glabella (1-5) *	-	
Mental Eminence (1-5) *	-	
Estimated Sex	Undetermined	

Notes:

In all cases (skull and pelvis) the left should be preferentially scored. When the left side is absent, the right can be scored.
* after observations described in Buikstra & Ubelaker 1994 (pp. 16-21):
0-3 scale: - (blank) = not observable; 1 = female; 2 = ambiguous; 3 = male
0-4 scale: - (blank) = no sulcus; 1 = sulcus is wide (>0.5cm) and deep; 2 = sulcus is wide but shallow; 3 = sulcus is well defined but narrow; 4 = sulcus is a narrow (<0.5cm), shallow, and smooth-walled depression.
0-5 scale: - (blank) = not observable; 1 = female; 2 = probable female; 3 = ambiguous; 4 = probable male; 5 = male

Age Estimation - Adult

Pubic Symphysis Scoring System (following Brooks and Suchey 1990; Suchey and Katz 1986)

	Left	Right
Phase	-	-

Notes:

Scoring: - = could not be assessed; phases 1-6 (see Buikstra and Ubelaker, 1994: 23-24)

Sex/Age Estimation Date: 26-May-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 95

Auricular Surface Scoring System – Transition Analysis (following Boldsen et al. 2002:101-103) (can record multiple stages for a single feature)[1]

	Left		Right	
	Min	Max	Min	Max
Superior Topography (1-3)	-	-	-	-
Inferior Topography (1-3)	-	-	-	-
Superior Characteristics (1-5)	-	-	-	-
Apical Characteristics (1-5)	-	-	-	-
Inferior Characteristics (1-5)	-	-	-	-
Inferior Texture (1-3)	-	-	-	-
Superior* Exostoses (1-6)	-	-	-	-
Inferior* Exostoses (1-6)	-	-	-	-
Posterior Exostoses (1-3)	-	-	-	-

Notes:

[1]Record the left auricular surface. When the left is absent, the right can be recorded but do not mix the two sides.
Scoring: - = could not be assessed; see Boldsen et al. 2002
* Superior and Inferior Posterior Iliac Crest

Summary Information – Adult Age and Sex

Age[1]	6 mos
Sex[2]	

[1]Young adult (20-34), middle adult (35-49), old adult (50+)
[2]After Buikstra and Ubelaker (1994: 21): undetermined; female; probable female; ambiguous; probable male; male

Date: 26-May-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 95

Juvenile Pathology Form

Cranium

	Left			Right		
	Present/ Absent	Abnormal Porosity	Abnormal Shape	Present/ Absent	Abnormal Porosity	Abnormal Shape
Frontal	absent	-	-	absent	-	-
Orbital roof	absent	-	-	absent	-	-
Parietal	absent	-	-	absent	-	-
Temporal	absent	-	-	absent	-	-
Maxilla	absent		-	absent		-
Mandibular ramus	absent		-	absent		-
Other	-	-	-	-	-	-

	Unsided		
Occipital	absent	-	-

Photo ☐

Notes: One small fragment of cranial vault preserved. Porous, but looks like normal bone growth. Most likely a parietal but unsided.

Scoring: - = feature not observable; 0 = feature absent; 1 = feature present

Ribs

	# Left (1-12)	# Right (1-12)	# Unsided (1-24)	Abnormal Porosity[1]	Flaring[1]	Fractures[2]	Cupping[3]
Proximal Ends	2	6					
Costochondral Ends			6	0	4	0	-
Abnormal rib curvature*	-	-					

Notes: Slight flaring on some, not all costochondral ends. Some porosity as well, but possible it is within normal variation.

* can only be assessed on complete ribs

[1] - Only assessed at costochondral ends.

[2] – If fracture is located somewhere other than costochondral end, indicate location and side (if possible in notes section.

[3] – indicates the total number of ribs exhibiting cupping

Scoring: - = not observable; indicate number of ribs with pathology

Photo ☒

Date: 26-May-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 95

Long Bones – Presence[1]

Element	LEFT					RIGHT				
	Prox epip	Prox 1/3	Mid 1/3	Distal 1/3	Distal epip	Prox epip	Prox 1/3	Mid 1/3	Distal 1/3	Distal epip
Clavicle	>75%	>75%	>75%	>75%	>75%	-	-	-	-	-
Humerus	-	-	-	-	-	>75%	>75%	>75%	>75%	>75%
Radius	-	-	-	-	-	>75%	>75%	>75%	>75%	>75%
Ulna	-	-	-	-	-	-	-	-	-	-
Femur	>75%	>75%	>75%	>75%	>75%	<25%	>75%	>75%	>75%	>75%
Tibia	>75%	>75%	>75%	>75%	>75%	>75%	>75%	>75%	>75%	>75%
Fibula	-	>75%	>75%	>75%	>75%	-	>75%	>75%	>75%	>75%

* segment preservation: - = not present; <25%; 25-50%; 50-75% >75%

Long Bones – Pathology

	Abnormal Growth Plate	Thickening	Abnormal Shaft Shape	Abnormal Metaphysis Shape	Other (features such as fracture)*
LEFT Side					
Clavicle		absent	absent	absent	absent
Humerus	-	-	-	-	-
Radius	-	-	-	-	-
Ulna	-	-	-	-	-
Femur	1	absent	present	absent	present
Tibia	1	absent	present	absent	absent
Fibula	1	absent	present	absent	absent

Notes: Anterior bowing of the femoral shafts, slight coxa vara visible in the left femur. Anterior bowing of the diaphysis of the tibia and fibula.

*Provide details about 'other' pathological features in the notes box.

** Indicate which bones/elements photographed in notes box.

[1] n/a is to be used when the growth plate is fused. Only the distal growth plate is scored. Scoring adopted from Mays et al. 2006.

Photo** ☒

Date: 26-May-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 95

Long Bones (continued)

	Abnormal Growth Plate[1]	Thickening	Abnormal Shaft Shape	Abnormal Metaphysis Shape	Other (features such as fracture)*
RIGHT Side					
Clavicle		-	-	-	-
Humerus	normal	absent	absent	absent	absent
Radius	normal	absent	absent	absent	absent
Ulna	-	-	-	-	-
Femur	1	absent	present	absent	absent
Tibia	1	absent	present	absent	absent
Fibula	1	absent	present	absent	absent

Notes: Anterior bowing of the diaphysis of the tibia, femur and fibula and slight roughening on the distal growth plates.

*Provide details about 'other' pathological features in the notes box.
** Indicate which bones/elements photographed in notes box.
[1] n/a is to be used when the growth plate is fused. Only the distal growth plate is scored. Scoring adopted from Mays et al. 2006.

Photo** ☒

Ilium (following Ortner and Brown 2011)

	Presence (%)	Abnormal Shape
Right ilium	>75%	absent
Left ilium	>75%	absent

Notes:

Photo ☐

- = not present; <25%; 25-50%; 50-75% >75%

Sacrum (only record if sufficiently complete to assess normal curvature)

	Presence (%)	Abnormal Shape
Sacrum	-	-

Notes: Not present

Photo ☐

X-rays required (y/n) (indicate in notes which bones/elements to be radiographed)	☐
X-rays completed (y/n)	☐

Summary

Possible Vitamin D deficiency present?	Yes

Sex/Age Estimation Date: 15-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 141

Age Estimation – Juvenile

Dental Development (following Gustafson and Koch 1974)

Deciduous Dentition

Maxilla	Left	Right	Unsided 1	Unsided 2
m^2	-	-	-	-
m^1	-	4	-	-
c	4	-	-	-
i^2	-	-	-	-
i^1	-	-	-	-

Mandible	Left	Right	Unsided 1	Unsided 2
m_2	-	-	-	-
m_1	-	-	-	-
c	-	-	-	-
i_2	-	-	-	-
i_1	-	-	-	-

Permanent Dentition

Maxilla	Left	Right	Unsided 1	Unsided 2
M^2	2	2	-	-
M^1	3.5	3.5	-	-
PM^2	3.5	-	-	-
PM^1	3.5	3	-	-
C	-	-	-	-
I^2	3.5	3.5	-	-
I^1	4	4	-	-

Mandible	Left	Right	Unsided 1	Unsided 2
M^2	-	-	-	-
M^1	-	-	-	-
PM^2	-	-	-	-
PM^1	-	-	-	-
C	-	-	-	-
I^2	-	-	-	-
I^1	-	-	-	-

Scoring: - = could not be assessed; 1 = start of mineralization; 1.5 = past start of mineralization, but not yet at complete crown; 2 = complete crown; 2.5 = crown complete, but not certain if eruption has occurred; 3 = eruption in progress; 3.5 eruption complete (teeth are in occlusion), but not certain if root is fully formed; 4 = eruption and root complete

If M3s are present, record side & development here: Max ____ Max ____ Mand ____ Mand _____

Long Bone Length (in mm)

	Left	Right
Femur	264	262
Tibia	213	212
Fibula	208	
Humerus		
Radius	149	150
Ulna	166	167

Notes:

Epiphyseal Fusion (following Cardoso 2008 a, b) - Fusion should be scored on **left** bone only. If left is not present right should be scored.

Femur: 1 - proximal epiphysis; 2 – greater trochanter; 3 – lesser trochanter; 4 – distal epiphysis
Tibia: 1 – proximal epiphysis; 2 – distal epiphysis
Humerus: 1 – proximal epiphysis; 2 – distal epiphysis; 3 – medial epicondyle
Radius: 1 – proximal epiphysis; 2 – distal epiphysis
Pelvis: 1 – iliac crest; 2 – ischial epiphysis
Clavicle: 1 – sternal epiphysis

	Side	Epiphysis 1	Epiphysis 2	Epiphysis 3	Epiphysis 4
Femur	left	1	1	1	1
Tibia	left	1	1		
Humerus	-	-	-	-	
Radius	left	1	1		
Pelvis	left	1	1		
Clavicle	left	1			
Other	-	-	-	-	-

Scoring: - = could not be assessed; 1 = non-union (epiphysis and diaphysis are completely separate); 2 = partial union; 3 – complete union (all visible aspects of epiphysis are united)

Sex/Age Estimation Date: 15-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 141

Summary Information

Dental Dev. Age Estimate	Long Bone Length Age Estimate	Epiphyseal Fusion Age Estimate	Dental Wear Age Estimate (if applicable)
9-10 years	5.5-7.5 years	7-12 years	

Notes: In terms of long bone length, the arms seem to be around 6-7 years, and the legs are aged more between 5-6 years.
Apex has not fused on dens on axis, and pars basilaris has fused to the lateralis.

Dental Wear (modified from Brothwell 1965) – for older adolescents and adults (M1 must be erupted and in occlusion)

Maxilla		
	Left	**Right**
M3	-	-
M2	-	-
M1	2	2

Mandible		
	Left	**Right**
M3	-	-
M2	-	-
M1	-	-

Modified scoring: - = could not be assessed; score - 1-13 (refer to diagram)

Notes:

Sex/Age Estimation Date: 15-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 141

Sex Estimation – Adult

Will not be attempted for those <16 years old. For those 16+ years the features of the skull/mandible and pelvis set out in Buikstra and Ubelaker (1994) will be used.

Pelvis	Left	Right
Ventral Arc (1-3) *	-	-
Subpubic Concavity (1-3) *	-	-
Ischiopubic Ramus Ridge (1-3) *	-	-
Greater Sciatic Notch (1-5) *	-	-
Preauricular Sulcus (1-4) *	-	-
Estimated Sex	Undeterminec	

Skull	Left	Right
Nuchal Crest (1-5) *	-	
Mastoid Process (1-5) *	-	-
Supraorbital Margin (1-5) *	-	-
Glabella (1-5) *	-	
Mental Eminence (1-5) *	-	
Estimated Sex	Undeterminec	

Notes:

In all cases (skull and pelvis) the left should be preferentially scored. When the left side is absent, the right can be scored.
* after observations described in Buikstra & Ubelaker 1994 (pp. 16-21):
0-3 scale: - (blank) = not observable; 1 = female; 2 = ambiguous; 3 = male
0-4 scale: - (blank) = no sulcus; 1 = sulcus is wide (>0.5cm) and deep; 2 = sulcus is wide but shallow; 3 = sulcus is well defined but narrow; 4 = sulcus is a narrow (<0.5cm), shallow, and smooth-walled depression.
0-5 scale: - (blank) = not observable; 1 = female; 2 = probable female; 3 = ambiguous; 4 = probable male; 5 = male

Age Estimation - Adult

Pubic Symphysis Scoring System (following Brooks and Suchey 1990; Suchey and Katz 1986)

	Left	Right
Phase	-	-

Notes:

Scoring: - = could not be assessed; phases 1-6 (see Buikstra and Ubelaker, 1994: 23-24)

Sex/Age Estimation Date: 15-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 141

Auricular Surface Scoring System – Transition Analysis (following Boldsen et al. 2002:101-103) (can record multiple stages for a single feature)[1]

	Left		Right	
	Min	Max	Min	Max
Superior Topography (1-3)	-	-	-	-
Inferior Topography (1-3)	-	-	-	-
Superior Characteristics (1-5)	-	-	-	-
Apical Characteristics (1-5)	-	-	-	-
Inferior Characteristics (1-5)	-	-	-	-
Inferior Texture (1-3)	-	-	-	-
Superior* Exostoses (1-6)	-	-	-	-
Inferior* Exostoses (1-6)	-	-	-	-
Posterior Exostoses (1-3)	-	-	-	-

Notes:

[1]Record the left auricular surface. When the left is absent, the right can be recorded but do not mix the two sides.
Scoring: - = could not be assessed; see Boldsen et al. 2002
* Superior and Inferior Posterior Iliac Crest

Summary Information – Adult Age and Sex

Age[1]	9-10 years
Sex[2]	

[1]Young adult (20-34), middle adult (35-49), old adult (50+)
[2]After Buikstra and Ubelaker (1994: 21): undetermined; female; probable female; ambiguous; probable male; male

Date: 15-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 141

Juvenile Pathology Form

Cranium

	Left			Right		
	Present/ Absent	Abnormal Porosity	Abnormal Shape	Present/ Absent	Abnormal Porosity	Abnormal Shape
Frontal	present	absent	absent	present	absent	absent
Orbital roof	present	present	absent	present	present	absent
Parietal	present	absent	absent	present	absent	absent
Temporal	present	absent	absent	present	absent	absent
Maxilla	present		absent	present		absent
Mandibular ramus	absent		-	absent		-
Other	-	-	-	-	-	-

	Unsided		
Occipital	present	absent	absent

Photo ☒

Notes: The maxillary left first incisor is misshapen. It is smaller and curves medially, and is slightly a different colour than the other first incisor. Possible trauma to the tooth interrupted it's growth.

Scoring: - = feature not observable; 0 = feature absent; 1 = feature present

Ribs

	# Left (1-12)	# Right (1-12)	# Unsided (1-24)	Abnormal Porosity[1]	Flaring[1]	Fractures[2]	Cupping[3]
Proximal Ends	11	10					
Costochondral Ends			9	-	-	-	-
Abnormal rib curvature*	-	-					

Notes:

* can only be assessed on complete ribs

[1] - Only assessed at costochondral ends.

[2] – If fracture is located somewhere other than costochondral end, indicate location and side (if possible in notes section.

[3] – indicates the total number of ribs exhibiting cupping

Scoring: - = not observable; indicate number of ribs with pathology

Photo ☐

Date: 15-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 141

Long Bones – Presence[1]

Element	LEFT					RIGHT				
	Prox epip	Prox 1/3	Mid 1/3	Distal 1/3	Distal epip	Prox epip	Prox 1/3	Mid 1/3	Distal 1/3	Distal epip
Clavicle	<25%	>75%	>75%	>75%	>75%	<25%	>75%	>75%	>75%	>75%
Humerus	-	-	-	-	-	-	-	-	-	-
Radius	>75%	>75%	>75%	>75%	>75%	<25%	>75%	>75%	>75%	>75%
Ulna	>75%	>75%	>75%	>75%	>75%	50-75%	>75%	>75%	>75%	<25%
Femur	>75%	>75%	>75%	>75%	>75%	>75%	>75%	>75%	>75%	>75%
Tibia	>75%	>75%	>75%	>75%	>75%	>75%	>75%	>75%	>75%	>75%
Fibula	>75%	>75%	>75%	>75%	>75%	<25%	>75%	>75%	>75%	-

* segment preservation: - = not present; <25%; 25-50%; 50-75% >75%

Long Bones – Pathology

	Abnormal Growth Plate	Thickening	Abnormal Shaft Shape	Abnormal Metaphysis Shape	Other (features such as fracture)*
LEFT Side					
Clavicle		absent	absent	absent	absent
Humerus	-	-	-	-	-
Radius	normal	absent	absent	absent	absent
Ulna	normal	absent	absent	absent	absent
Femur	normal	absent	absent	absent	absent
Tibia	normal	absent	present	absent	absent
Fibula	normal	absent	absent	absent	absent

Notes: Possible bowing of the distal third of the diaphysis. Bowing laterally.

*Provide details about ‘other’ pathological features in the notes box.

** Indicate which bones/elements photographed in notes box.

[1] n/a is to be used when the growth plate is fused. Only the distal growth plate is scored. Scoring adopted from Mays et al. 2006.

Photo** ☒

Date: 15-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 141

Long Bones (continued)

	Abnormal Growth Plate[1]	Thickening	Abnormal Shaft Shape	Abnormal Metaphysis Shape	Other (features such as fracture)*
RIGHT Side					
Clavicle		absent	absent	absent	absent
Humerus	-	-	-	-	-
Radius	normal	absent	absent	absent	absent
Ulna	normal	absent	absent	absent	absent
Femur	normal	absent	absent	absent	absent
Tibia	normal	absent	present	absent	absent
Fibula	-	absent	absent	absent	absent
Notes: Possible lateral bowing of distal diaphysis of tibia. Humeri missing, yet well preserved skeleton - must be somewhere in a pathology box? Notes for this individual mention that the right humerus is noticeably shorter than the other. (clear asymmetry) .					

*Provide details about 'other' pathological features in the notes box.

** Indicate which bones/elements photographed in notes box.

[1] n/a is to be used when the growth plate is fused. Only the distal growth plate is scored. Scoring adopted from Mays et al. 2006.

Photo** ☒

Ilium (following Ortner and Brown 2011)

	Presence (%)	Abnormal Shape
Right ilium	>75%	absent
Left ilium	>75%	absent

Notes:

- = not present; <25%; 25-50%; 50-75% >75%

Photo ☐

Sacrum (only record if sufficiently complete to assess normal curvature)

	Presence (%)	Abnormal Shape
Sacrum	-	-

Notes:

Photo ☐

X-rays required (y/n) (indicate in notes which bones/elements to be radiographed)	☐
X-rays completed (y/n)	☐

Summary

Possible Vitamin D deficiency present?	Yes

Sex/Age Estimation Date: May 20, 2015 Site Lisieux-Michelet

Observer: Lisa Sk # 144

Age Estimation – Juvenile

Dental Development (following Gustafson and Koch 1974)

Deciduous Dentition

Maxilla

	Left	Right	Unsided 1	Unsided 2
m^2	-	-	-	-
m^1	-	-	-	-
c	-	-	-	-
i^2	-	-	-	-
i^1	-	-	-	-

Mandible

	Left	Right	Unsided 1	Unsided 2
m_2	-	-	-	3.5
m_1	-	-	-	-
c	-	-	-	-
i_2	-	-	-	-
i_1	-	-	-	3.5

Permanent Dentition

Maxilla

	Left	Right	Unsided 1	Unsided 2
M^2	-	-	-	-
M^1	-	-	-	-
PM^2	-	-	-	-
PM^1	-	-	-	-
C	-	-	-	-
I^2	-	-	-	-
I^1	-	-	-	-

Mandible

	Left	Right	Unsided 1	Unsided 2
M^2	-	-	-	-
M^1	-	-	-	-
PM^2	-	-	-	-
PM^1	-	-	-	-
C	-	-	-	-
I^2	-	-	-	-
I^1	-	-	-	-

Scoring: - = could not be assessed; 1 = start of mineralization; 1.5 = past start of mineralization, but not yet at complete crown; 2 = complete crown; 2.5 = crown complete, but not certain if eruption has occurred; 3 = eruption in progress; 3.5 eruption complete (teeth are in occlusion), but not certain if root is fully formed; 4 = eruption and root complete

If M3s are present, record side & development here: Max ____ Max ____ Mand ____ Mand _____

Long Bone Length
(in mm)

	Left	Right
Femur		
Tibia		
Fibula		
Humerus		
Radius		
Ulna		

Notes: Other = proximal epiphysis of ulna. Individual has unfused neural arches, unfused neural arches to vertebral bodies, unfused metopic suture (<4 years).

Epiphyseal Fusion (following Cardoso 2008 a, b) - Fusion should be scored on **left** bone only. If left is not present right should be scored.

Femur: 1 - proximal epiphysis; 2 – greater trochanter; 3 – lesser trochanter; 4 – distal epiphysis
Tibia: 1 – proximal epiphysis; 2 – distal epiphysis
Humerus: 1 – proximal epiphysis; 2 – distal epiphysis; 3 – medial epicondyle
Radius: 1 – proximal epiphysis; 2 – distal epiphysis
Pelvis: 1 – iliac crest; 2 – ischial epiphysis
Clavicle: 1 – sternal epiphysis

	Side	Epiphysis 1	Epiphysis 2	Epiphysis 3	Epiphysis 4
Femur	left	1	1	-	-
Tibia	left	-	-		
Humerus	left	1	-	-	
Radius	left	-	-		
Pelvis	left	1	-		
Clavicle	left	1			
Other	left	1	-	-	-

Scoring: - = could not be assessed; 1 = non-union (epiphysis and diaphysis are completely separate); 2 = partial union; 3 – complete union (all visible aspects of epiphysis are united)

Sex/Age Estimation Date: May 20, 2015 Site Lisieux-Michelet

Observer: Lisa Sk # 144

Summary Information

Dental Dev. Age Estimate	Long Bone Length Age Estimate	Epiphyseal Fusion Age Estimate	Dental Wear Age Estimate (if applicable)
7 months - 1.5 years	-	< 14 years	-

Notes: Juvenile likely between 7 months - 1.5 years old based on dental development, unfused vertebrae and unfused metopic suture

Dental Wear (modified from Brothwell 1965) – for older adolescents and adults (M1 must be erupted and in occlusion)

Maxilla		
	Left	**Right**
M3	-	-
M2	-	-
M1	-	-

Mandible		
	Left	**Right**
M3	-	-
M2	-	-
M1	-	-

Modified scoring: - = could not be assessed; score - 1-13 (refer to diagram)

Notes:

Sex/Age Estimation Date: May 20, 2015 Site Lisieux-Michelet

Observer: Lisa Sk # 144

Sex Estimation – Adult

Will not be attempted for those <16 years old. For those 16+ years the features of the skull/mandible and pelvis set out in Buikstra and Ubelaker (1994) will be used.

Pelvis		
	Left	**Right**
Ventral Arc (1-3) *	-	-
Subpubic Concavity (1-3) *	-	-
Ischiopubic Ramus Ridge (1-3) *	-	-
Greater Sciatic Notch (1-5) *	-	-
Preauricular Sulcus (1-4) *	-	-
Estimated Sex	Undeterminec	

Skull		
	Left	**Right**
Nuchal Crest (1-5) *	-	
Mastoid Process (1-5) *	-	-
Supraorbital Margin (1-5) *	-	-
Glabella (1-5) *	-	
Mental Eminence (1-5) *	-	
Estimated Sex	Undeterminec	

Notes:

In all cases (skull and pelvis) the left should be preferentially scored. When the left side is absent, the right can be scored.
* after observations described in Buikstra & Ubelaker 1994 (pp. 16-21):
0-3 scale: - (blank) = not observable; 1 = female; 2 = ambiguous; 3 = male
0-4 scale: - (blank) = no sulcus; 1 = sulcus is wide (>0.5cm) and deep; 2 = sulcus is wide but shallow; 3 = sulcus is well defined but narrow; 4 = sulcus is a narrow (<0.5cm), shallow, and smooth-walled depression.
0-5 scale: - (blank) = not observable; 1 = female; 2 = probable female; 3 = ambiguous; 4 = probable male; 5 = male

Age Estimation - Adult

Pubic Symphysis Scoring System (following Brooks and Suchey 1990; Suchey and Katz 1986)

	Left	**Right**
Phase	-	-

Notes:

Scoring: - = could not be assessed; phases 1-6 (see Buikstra and Ubelaker, 1994: 23-24)

Sex/Age Estimation Date: May 20, 2015 Site Lisieux-Michelet

Observer: Lisa Sk # 144

Auricular Surface Scoring System – Transition Analysis (following Boldsen et al. 2002:101-103) (can record multiple stages for a single feature)[1]

	Left		Right	
	Min	Max	Min	Max
Superior Topography (1-3)	-	-	-	-
Inferior Topography (1-3)	-	-	-	-
Superior Characteristics (1-5)	-	-	-	-
Apical Characteristics (1-5)	-	-	-	-
Inferior Characteristics (1-5)	-	-	-	-
Inferior Texture (1-3)	-	-	-	-
Superior* Exostoses (1-6)	-	-	-	-
Inferior* Exostoses (1-6)	-	-	-	-
Posterior Exostoses (1-3)	-	-	-	-

Notes:

[1]Record the left auricular surface. When the left is absent, the right can be recorded but do not mix the two sides.
Scoring: - = could not be assessed; see Boldsen et al. 2002
* Superior and Inferior Posterior Iliac Crest

Summary Information – Adult Age and Sex

Age[1]	7 months - 1.5 years
Sex[2]	-

[1]Young adult (20-34), middle adult (35-49), old adult (50+)
[2]After Buikstra and Ubelaker (1994: 21): undetermined; female; probable female; ambiguous; probable male; male

Date: 20-May-2015 Site Lisieux-Michelet

Observer: Lisa Sk # 144

Juvenile Pathology Form

Cranium

	Left			Right		
	Present/ Absent	Abnormal Porosity	Abnormal Shape	Present/ Absent	Abnormal Porosity	Abnormal Shape
Frontal	present	absent	-	present	absent	-
Orbital roof	present	absent	-	present	absent	-
Parietal	present	absent	-	present	absent	-
Temporal	present	absent	-	present	absent	-
Maxilla	-		-	-		-
Mandibular ramus	-		-	-		-
Other	-	-	-	-	-	-

	Unsided		
Occipital	present	absent	-

Photo ☐

Notes:

Scoring: - = feature not observable; 0 = feature absent; 1 = feature present

Ribs

	# Left (1-12)	# Right (1-12)	# Unsided (1-24)	Abnormal Porosity[1]	Flaring[1]	Fractures[2]	Cupping[3]
Proximal Ends	9	11					
Costochondral Ends			10	0	5	-	-
Abnormal rib curvature*	2	2					

Notes: Flaring in costochondral ends (photos) and abnormal curvature (photos).

* can only be assessed on complete ribs
[1] - Only assessed at costochondral ends.
[2] – If fracture is located somewhere other than costochondral end, indicate location and side (if possible in notes section.
[3] – indicates the total number of ribs exhibiting cupping
Scoring: - = not observable; indicate number of ribs with pathology

Photo ☒

Date: 20-May-2015 Site Lisieux-Michelet

Observer: Lisa Sk # 144

Long Bones – Presence[1]

Element	LEFT					RIGHT				
	Prox epip	**Prox 1/3**	**Mid 1/3**	**Distal 1/3**	**Distal epip**	**Prox epip**	**Prox 1/3**	**Mid 1/3**	**Distal 1/3**	**Distal epip**
Clavicle	>75%	>75%	>75%	>75%	-	>75%	>75%	>75%	>75%	>75%
Humerus	>75%	>75%	>75%	>75%	-	<25%	>75%	>75%	>75%	<25%
Radius	-	50-75%	>75%	50-75%	-	-	>75%	>75%	>75%	-
Ulna	>75%	50-75%	50-75%	-	-	>75%	>75%	25-50%	-	-
Femur	25-50%	>75%	>75%	50-75%	-	50-75%	>75%	>75%	50-75%	-
Tibia	-	>75%	>75%	>75%	-	-	>75%	>75%	>75%	-
Fibula	-	<25%	50-75%	<25%	-	-	-	-	-	-

* segment preservation: - = not present; <25%; 25-50%; 50-75% >75%

Long Bones – Pathology

	Abnormal Growth Plate	Thickening	Abnormal Shaft Shape	Abnormal Metaphysis Shape	Other (features such as fracture)*
LEFT Side					
Clavicle		absent	absent	absent	absent
Humerus	-	absent	absent	absent	absent
Radius	-	absent	-	-	absent
Ulna	-	absent	-	-	absent
Femur	-	absent	-	-	present
Tibia	-	absent	-	-	absent
Fibula	-	absent	-	-	absent

Notes: Slight coxa vera of femur (photo).

*Provide details about 'other' pathological features in the notes box.

** Indicate which bones/elements photographed in notes box.

[1] n/a is to be used when the growth plate is fused. Only the distal growth plate is scored. Scoring adopted from Mays et al. 2006.

Photo** ☒

Date: 20-May-2015 Site Lisieux-Michelet

Observer: Lisa Sk # 144

Long Bones (continued)

	Abnormal Growth Plate[1]	Thickening	Abnormal Shaft Shape	Abnormal Metaphysis Shape	Other (features such as fracture)*
RIGHT Side					
Clavicle		absent	absent	absent	absent
Humerus	-	absent	absent	absent	absent
Radius	-	absent	absent	absent	absent
Ulna	-	absent	-	-	absent
Femur	-	absent	-	-	present
Tibia	-	absent	-	-	absent
Fibula	-	-	-	-	-
Notes: Slight coxa vera of femur (photo),.					

*Provide details about 'other' pathological features in the notes box.

** Indicate which bones/elements photographed in notes box.

[1] n/a is to be used when the growth plate is fused. Only the distal growth plate is scored. Scoring adopted from Mays et al. 2006.

Photo** ☒

Ilium (following Ortner and Brown 2011)

	Presence (%)	Abnormal Shape
Right ilium	>75%	absent
Left ilium	>75%	absent

Notes:

- = not present; <25%; 25-50%; 50-75% >75%

Photo ☐

Sacrum (only record if sufficiently complete to assess normal curvature)

	Presence (%)	Abnormal Shape
Sacrum	-	-

Notes:

Photo ☐

X-rays required (y/n) (indicate in notes which bones/elements to be radiographed)	☐
X-rays completed (y/n)	☐

Summary

Possible Vitamin D deficiency present?	Yes

Sex/Age Estimation Date: 12-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 234

Age Estimation – Juvenile

Dental Development (following Gustafson and Koch 1974)

Deciduous Dentition

Maxilla	Left	Right	Unsided 1	Unsided 2
m^2	-	-	-	-
m^1	-	-	-	-
c	-	-	-	-
i^2	-	-	-	-
i^1	-	-	-	-

Mandible	Left	Right	Unsided 1	Unsided 2
m_2	-	-	-	-
m_1	-	-	-	-
c	-	-	-	-
i_2	-	-	-	-
i_1	-	-	-	-

Permanent Dentition

Maxilla	Left	Right	Unsided 1	Unsided 2
M^2	-	-	-	-
M^1	-	-	-	-
PM^2	-	-	-	-
PM^1	-	-	-	-
C	-	-	-	-
I^2	-	-	-	-
I^1	-	-	-	-

Mandible	Left	Right	Unsided 1	Unsided 2
M^2	-	-	-	-
M^1	-	-	-	-
PM^2	-	-	-	-
PM^1	-	-	-	-
C	-	-	-	-
I^2	-	-	-	-
I^1	-	-	-	-

Scoring: - = could not be assessed; 1 = start of mineralization; 1.5 = past start of mineralization, but not yet at complete crown; 2 = complete crown; 2.5 = crown complete, but not certain if eruption has occurred; 3 = eruption in progress; 3.5 eruption complete (teeth are in occlusion), but not certain if root is fully formed; 4 = eruption and root complete

If M3s are present, record side & development here: Max ____ Max ____ Mand ____ Mand _____

Long Bone Length
(in mm)

	Left	Right
Femur	185	185
Tibia		149
Fibula		
Humerus	134	135
Radius		
Ulna		

Notes: No dentition.

Epiphyseal Fusion (following Cardoso 2008 a, b) - Fusion should be scored on **left** bone only. If left is not present right should be scored.

Femur: 1 - proximal epiphysis; 2 – greater trochanter; 3 – lesser trochanter; 4 – distal epiphysis
Tibia: 1 – proximal epiphysis; 2 – distal epiphysis
Humerus: 1 – proximal epiphysis; 2 – distal epiphysis; 3 – medial epicondyle
Radius: 1 – proximal epiphysis; 2 – distal epiphysis
Pelvis: 1 – iliac crest; 2 – ischial epiphysis
Clavicle: 1 – sternal epiphysis

	Side	Epiphysis 1	Epiphysis 2	Epiphysis 3	Epiphysis 4
Femur	left	1	1	1	1
Tibia	left	1	1		
Humerus	left	1	1	1	
Radius	left	1	-		
Pelvis	right	1	1		
Clavicle	-	-			
Other	-	-	-	-	-

Scoring: - = could not be assessed; 1 = non-union (epiphysis and diaphysis are completely separate); 2 = partial union; 3 – complete union (all visible aspects of epiphysis are united)

Sex/Age Estimation Date: 12-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 234

Summary Information

Dental Dev. Age Estimate	Long Bone Length Age Estimate	Epiphyseal Fusion Age Estimate	Dental Wear Age Estimate (if applicable)
N/A	2-2.5 years	3-4 years	
Notes: Centrum not fused to arches of axis. No cervical vertebral bodies fused or fusing. Lumbar bodies have fused. Pars Lateralis and basilaris are not fused.			

Dental Wear (modified from Brothwell 1965) – for older adolescents and adults (M1 must be erupted and in occlusion)

Maxilla		
	Left	**Right**
M3	-	-
M2	-	-
M1	-	-

Mandible		
	Left	**Right**
M3	-	-
M2	-	-
M1	-	-

Modified scoring: - = could not be assessed; score - 1-13 (refer to diagram)

Notes:

Sex/Age Estimation Date: 12-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 234

Sex Estimation – Adult

Will not be attempted for those <16 years old. For those 16+ years the features of the skull/mandible and pelvis set out in Buikstra and Ubelaker (1994) will be used.

Pelvis	Left	Right
Ventral Arc (1-3) *	-	-
Subpubic Concavity (1-3) *	-	-
Ischiopubic Ramus Ridge (1-3) *	-	-
Greater Sciatic Notch (1-5) *	-	-
Preauricular Sulcus (1-4) *	-	-
Estimated Sex	Undeterminec	

Skull	Left	Right
Nuchal Crest (1-5) *	-	
Mastoid Process (1-5) *	-	-
Supraorbital Margin (1-5) *	-	-
Glabella (1-5) *	-	
Mental Eminence (1-5) *	-	
Estimated Sex	Undeterminec	

Notes:

In all cases (skull and pelvis) the left should be preferentially scored. When the left side is absent, the right can be scored.
* after observations described in Buikstra & Ubelaker 1994 (pp. 16-21):
0-3 scale: - (blank) = not observable; 1 = female; 2 = ambiguous; 3 = male
0-4 scale: - (blank) = no sulcus; 1 = sulcus is wide (>0.5cm) and deep; 2 = sulcus is wide but shallow; 3 = sulcus is well defined but narrow; 4 = sulcus is a narrow (<0.5cm), shallow, and smooth-walled depression.
0-5 scale: - (blank) = not observable; 1 = female; 2 = probable female; 3 = ambiguous; 4 = probable male; 5 = male

Age Estimation - Adult

Pubic Symphysis Scoring System (following Brooks and Suchey 1990; Suchey and Katz 1986)

	Left	Right
Phase	-	-

Notes:

Scoring: - = could not be assessed; phases 1-6 (see Buikstra and Ubelaker, 1994: 23-24)

Sex/Age Estimation Date: 12-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 234

Auricular Surface Scoring System – Transition Analysis (following Boldsen et al. 2002:101-103) (can record multiple stages for a single feature)[1]

	Left		**Right**	
	Min	Max	Min	Max
Superior Topography (1-3)	-	-	-	-
Inferior Topography (1-3)	-	-	-	-
Superior Characteristics (1-5)	-	-	-	-
Apical Characteristics (1-5)	-	-	-	-
Inferior Characteristics (1-5)	-	-	-	-
Inferior Texture (1-3)	-	-	-	-
Superior* Exostoses (1-6)	-	-	-	-
Inferior* Exostoses (1-6)	-	-	-	-
Posterior Exostoses (1-3)	-	-	-	-

Notes:

[1]Record the left auricular surface. When the left is absent, the right can be recorded but do not mix the two sides.
Scoring: - = could not be assessed; see Boldsen et al. 2002
* Superior and Inferior Posterior Iliac Crest

Summary Information – Adult Age and Sex

Age[1]	3-4 years
Sex[2]	

[1]Young adult (20-34), middle adult (35-49), old adult (50+)
[2]After Buikstra and Ubelaker (1994: 21): undetermined; female; probable female; ambiguous; probable male; male

Date: 12-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 234

Juvenile Pathology Form

Cranium

	Left			Right		
	Present/ Absent	Abnormal Porosity	Abnormal Shape	Present/ Absent	Abnormal Porosity	Abnormal Shape
Frontal	present	absent	absent	present	absent	absent
Orbital roof	present	absent	absent	present	absent	absent
Parietal	present	absent	absent	present	absent	absent
Temporal	present	absent	absent	present	absent	absent
Maxilla	absent		-	absent		-
Mandibular ramus	absent		-	absent		-
Other	-	-	-	-	-	-

	Unsided		
Occipital	present	absent	absent

Photo

Notes:

Scoring: - = feature not observable; 0 = feature absent; 1 = feature present

Ribs

	# Left (1-12)	# Right (1-12)	# Unsided (1-24)	Abnormal Porosity[1]	Flaring[1]	Fractures[2]	Cupping[3]
Proximal Ends	6	7					
Costochondral Ends			8	-	-	-	-
Abnormal rib curvature*	-	-					

Notes:

* can only be assessed on complete ribs
[1] - Only assessed at costochondral ends.
[2] – If fracture is located somewhere other than costochondral end, indicate location and side (if possible in notes section.
[3] – indicates the total number of ribs exhibiting cupping
Scoring: - = not observable; indicate number of ribs with pathology

Photo

Date: 12-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 234

Long Bones – Presence[1]

Element	LEFT					RIGHT				
	Prox epip	Prox 1/3	Mid 1/3	Distal 1/3	Distal epip	Prox epip	Prox 1/3	Mid 1/3	Distal 1/3	Distal epip
Clavicle	-	-	-	-	-	-	-	-	-	-
Humerus	>75%	>75%	>75%	>75%	<25%	50-75%	>75%	>75%	>75%	25-50%
Radius	<25%	>75%	>75%	25-50%	-	-	>75%	>75%	>75%	-
Ulna	<25%	>75%	<25%	-	-	-	-	-	-	-
Femur	<25%	>75%	>75%	>75%	>75%	50-75%	>75%	>75%	>75%	>75%
Tibia	>75%	>75%	>75%	50-75%	-	>75%	>75%	>75%	>75%	>75%
Fibula	-	-	<25%	-	-	>75%	>75%	<25%	-	-

* segment preservation: - = not present; <25%; 25-50%; 50-75% >75%

Long Bones – Pathology

	Abnormal Growth Plate	Thickening	Abnormal Shaft Shape	Abnormal Metaphysis Shape	Other (features such as fracture)*
LEFT Side					
Clavicle		-	-	-	-
Humerus	normal	absent	absent	absent	absent
Radius	-	absent	absent	absent	absent
Ulna	-	absent	absent	absent	absent
Femur	1	absent	absent	present	absent
Tibia	-	absent	absent	absent	absent
Fibula	-	-	-	-	-

Notes: Velvet texture of distal growth plate of femur. The distal metaphyses may be flared.

*Provide details about 'other' pathological features in the notes box.

** Indicate which bones/elements photographed in notes box.

[1] n/a is to be used when the growth plate is fused. Only the distal growth plate is scored. Scoring adopted from Mays et al. 2006.

Photo** ☒

Date: 12-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 234

Long Bones (continued)

	Abnormal Growth Plate[1]	Thickening	Abnormal Shaft Shape	Abnormal Metaphysis Shape	Other (features such as fracture)*
RIGHT Side					
Clavicle		-	-	-	-
Humerus	normal	absent	absent	absent	absent
Radius	-	absent	absent	absent	absent
Ulna	-	-	-	-	-
Femur	1	absent	present	present	absent
Tibia	normal	absent	absent	absent	absent
Fibula	-	absent	absent	absent	absent

Notes: Distal growth plate of femur velvet texture, possible anterior bowing of the midshaft, and distal metaphysis may be flared.

*Provide details about 'other' pathological features in the notes box.
** Indicate which bones/elements photographed in notes box.
[1] n/a is to be used when the growth plate is fused. Only the distal growth plate is scored. Scoring adopted from Mays et al. 2006.

Photo** ☒

Ilium (following Ortner and Brown 2011)

	Presence (%)	Abnormal Shape
Right ilium	>75%	absent
Left ilium	50-75%	absent

Notes:

- = not present; <25%; 25-50%; 50-75% >75%

Photo ☐

Sacrum (only record if sufficiently complete to assess normal curvature)

	Presence (%)	Abnormal Shape
Sacrum	-	-

Notes:

Photo ☐

X-rays required (y/n) (indicate in notes which bones/elements to be radiographed)	☐
X-rays completed (y/n)	☐

Summary

Possible Vitamin D deficiency present?	Yes

Sex/Age Estimation Date: 22 May 2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 277

Age Estimation – Juvenile

Dental Development (following Gustafson and Koch 1974)

Deciduous Dentition

Maxilla	Left	Right	Unsided 1	Unsided 2
m^2	-	-	-	-
m^1	-	-	-	-
c	-	-	-	-
i^2	-	-	-	-
i^1	-	-	-	-

Mandible	Left	Right	Unsided 1	Unsided 2
m_2	-	-	-	-
m_1	-	-	-	-
c	-	-	-	-
i_2	-	-	-	-
i_1	-	-	-	-

Permanent Dentition

Maxilla	Left	Right	Unsided 1	Unsided 2
M^2	-	-	-	-
M^1	-	-	-	-
PM^2	-	-	-	-
PM^1	-	-	-	-
C	-	-	1.5	-
I^2	-	-	-	-
I^1	-	-	-	-

Mandible	Left	Right	Unsided 1	Unsided 2
M^2	-	-	-	-
M^1	-	-	-	-
PM^2	-	-	-	-
PM^1	-	-	-	-
C	-	-	-	-
I^2	-	-	-	-
I^1	-	-	-	-

Scoring: - = could not be assessed; 1 = start of mineralization; 1.5 = past start of mineralization, but not yet at complete crown; 2 = complete crown; 2.5 = crown complete, but not certain if eruption has occurred; 3 = eruption in progress; 3.5 eruption complete (teeth are in occlusion), but not certain if root is fully formed; 4 = eruption and root complete

If M3s are present, record side & development here: Max ____ Max ____ Mand ____ Mand _____

Long Bone Length (in mm)

	Left	Right
Femur	98	
Tibia		
Fibula		
Humerus		
Radius		
Ulna		

Notes: Femur approximate length. No other complete long bones.

Epiphyseal Fusion (following Cardoso 2008 a, b) - Fusion should be scored on **left** bone only. If left is not present right should be scored.

Femur: 1 - proximal epiphysis; 2 – greater trochanter; 3 – lesser trochanter; 4 – distal epiphysis
Tibia: 1 – proximal epiphysis; 2 – distal epiphysis
Humerus: 1 – proximal epiphysis; 2 – distal epiphysis; 3 – medial epicondyle
Radius: 1 – proximal epiphysis; 2 – distal epiphysis
Pelvis: 1 – iliac crest; 2 – ischial epiphysis
Clavicle: 1 – sternal epiphysis

	Side	Epiphysis 1	Epiphysis 2	Epiphysis 3	Epiphysis 4
Femur	-	-	-	-	-
Tibia	-	-	-		
Humerus	-	-	-	-	
Radius	-	-	-		
Pelvis	-	-	-		
Clavicle	-	-			
Other	-	-	-	-	-

Scoring: - = could not be assessed; 1 = non-union (epiphysis and diaphysis are completely separate); 2 = partial union; 3 – complete union (all visible aspects of epiphysis are united)

Sex/Age Estimation Date: 22 May 2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 277

Summary Information

Dental Dev. Age Estimate	Long Bone Length Age Estimate	Epiphyseal Fusion Age Estimate	Dental Wear Age Estimate (if applicable)
less than 5 mos	3 mos		
Notes: 3-5mos			

Dental Wear (modified from Brothwell 1965) – for older adolescents and adults (M1 must be erupted and in occlusion)

Maxilla		
	Left	**Right**
M3	-	-
M2	-	-
M1	-	-

Mandible		
	Left	**Right**
M3	-	-
M2	-	-
M1	-	-

Modified scoring: - = could not be assessed; score - 1-13 (refer to diagram)

Notes:

Sex/Age Estimation Date: 22 May 2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 277

Sex Estimation – Adult

Will not be attempted for those <16 years old. For those 16+ years the features of the skull/mandible and pelvis set out in Buikstra and Ubelaker (1994) will be used.

Pelvis	Left	Right
Ventral Arc (1-3) *	-	-
Subpubic Concavity (1-3) *	-	-
Ischiopubic Ramus Ridge (1-3) *	-	-
Greater Sciatic Notch (1-5) *	-	-
Preauricular Sulcus (1-4) *	-	-
Estimated Sex	Undeterminec	

Skull	Left	Right
Nuchal Crest (1-5) *	-	
Mastoid Process (1-5) *	-	-
Supraorbital Margin (1-5) *	-	-
Glabella (1-5) *	-	
Mental Eminence (1-5) *	-	
Estimated Sex	Undeterminec	

Notes:

In all cases (skull and pelvis) the left should be preferentially scored. When the left side is absent, the right can be scored.
* after observations described in Buikstra & Ubelaker 1994 (pp. 16-21):
0-3 scale: - (blank) = not observable; 1 = female; 2 = ambiguous; 3 = male
0-4 scale: - (blank) = no sulcus; 1 = sulcus is wide (>0.5cm) and deep; 2 = sulcus is wide but shallow; 3 = sulcus is well defined but narrow; 4 = sulcus is a narrow (<0.5cm), shallow, and smooth-walled depression.
0-5 scale: - (blank) = not observable; 1 = female; 2 = probable female; 3 = ambiguous; 4 = probable male; 5 = male

Age Estimation - Adult

Pubic Symphysis Scoring System (following Brooks and Suchey 1990; Suchey and Katz 1986)

	Left	Right
Phase	-	-

Notes:

Scoring: - = could not be assessed; phases 1-6 (see Buikstra and Ubelaker, 1994: 23-24)

Sex/Age Estimation Date: 22 May 2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 277

Auricular Surface Scoring System – Transition Analysis (following Boldsen et al. 2002:101-103) (can record multiple stages for a single feature)[1]

	Left		Right	
	Min	Max	Min	Max
Superior Topography (1-3)	-	-	-	-
Inferior Topography (1-3)	-	-	-	-
Superior Characteristics (1-5)	-	-	-	-
Apical Characteristics (1-5)	-	-	-	-
Inferior Characteristics (1-5)	-	-	-	-
Inferior Texture (1-3)	-	-	-	-
Superior* Exostoses (1-6)	-	-	-	-
Inferior* Exostoses (1-6)	-	-	-	-
Posterior Exostoses (1-3)	-	-	-	-

Notes:

[1]Record the left auricular surface. When the left is absent, the right can be recorded but do not mix the two sides.
Scoring: - = could not be assessed; see Boldsen et al. 2002
* Superior and Inferior Posterior Iliac Crest

Summary Information – Adult Age and Sex

Age[1]	3-5 mos
Sex[2]	

[1]Young adult (20-34), middle adult (35-49), old adult (50+)
[2]After Buikstra and Ubelaker (1994: 21): undetermined; female; probable female; ambiguous; probable male; male

Date: 26-May-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 277

Juvenile Pathology Form

Cranium

	Left			Right		
	Present/ Absent	Abnormal Porosity	Abnormal Shape	Present/ Absent	Abnormal Porosity	Abnormal Shape
Frontal	absent	-	-	absent	-	-
Orbital roof	absent	-	-	absent	-	-
Parietal	present	absent	absent	absent	-	-
Temporal	absent	-	-	absent	-	-
Maxilla	absent		-	absent		-
Mandibular ramus	absent		-	absent		-
Other	-	-	-	-	-	-

	Unsided		
Occipital	present	absent	absent

Photo

Notes: Some porosity on the occipital, but looks like new baby bone growth.

Scoring: - = feature not observable; 0 = feature absent; 1 = feature present

Ribs

	# Left (1-12)	# Right (1-12)	# Unsided (1-24)	Abnormal Porosity[1]	Flaring[1]	Fractures[2]	Cupping[3]
Proximal Ends	-	-					
Costochondral Ends			-	-	-	-	-
Abnormal rib curvature*	-	-					

Notes: No ribs preserved.

* can only be assessed on complete ribs

[1] - Only assessed at costochondral ends.

[2] – If fracture is located somewhere other than costochondral end, indicate location and side (if possible in notes section.

[3] – indicates the total number of ribs exhibiting cupping

Scoring: - = not observable; indicate number of ribs with pathology

Photo

Date: 26-May-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 277

Long Bones – Presence[1]

Element	LEFT					RIGHT				
	Prox epip	Prox 1/3	Mid 1/3	Distal 1/3	Distal epip	Prox epip	Prox 1/3	Mid 1/3	Distal 1/3	Distal epip
Clavicle	-	-	-	-	-	-	-	-	-	-
Humerus	-	-	-	-	-	<25%	50-75%	>75%	<25%	-
Radius	-	-	-	-	-	-	-	-	-	-
Ulna	-	-	-	-	-	-	-	-	-	-
Femur	<25%	50-75%	>75%	>75%	>75%	-	<25%	50-75%	>75%	>75%
Tibia	50-75%	50-75%	<25%	-	-	<25%	50-75%	<25%	-	-
Fibula	-	-	-	-	-	-	-	-	-	-

* segment preservation: - = not present; <25%; 25-50%; 50-75% >75%

Long Bones – Pathology

	Abnormal Growth Plate	Thickening	Abnormal Shaft Shape	Abnormal Metaphysis Shape	Other (features such as fracture)*
LEFT Side					
Clavicle		-	-	-	-
Humerus	-	-	-	-	-
Radius	-	-	-	-	-
Ulna	-	-	-	-	-
Femur	1	absent	absent	present	absent
Tibia	-	absent	-	absent	absent
Fibula	-	-	-	-	-

Notes: Distal ends of femora appear flared, unable to assess coxa vara. Photo of distal end of femora and growth plates.

*Provide details about 'other' pathological features in the notes box.

** Indicate which bones/elements photographed in notes box.

[1] n/a is to be used when the growth plate is fused. Only the distal growth plate is scored. Scoring adopted from Mays et al. 2006.

Photo** ☒

Date: 26-May-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 277

Long Bones (continued)

	Abnormal Growth Plate[1]	Thickening	Abnormal Shaft Shape	Abnormal Metaphysis Shape	Other (features such as fracture)*
RIGHT Side					
Clavicle		-	-	-	-
Humerus	-	absent	absent	absent	absent
Radius	-	-	-	-	-
Ulna	-	-	-	-	-
Femur	2	absent	absent	present	absent
Tibia	-	-	-	-	-
Fibula	-	-	-	-	-

Notes: Distal femora appear thickened. Distal growth plate of femur is rough and porous. Long bones feel light and frail when compared to other individuals at same age.

*Provide details about 'other' pathological features in the notes box.
** Indicate which bones/elements photographed in notes box.
[1] n/a is to be used when the growth plate is fused. Only the distal growth plate is scored. Scoring adopted from Mays et al. 2006.

Photo** ☒

Ilium (following Ortner and Brown 2011)

	Presence (%)	Abnormal Shape
Right ilium	-	-
Left ilium	-	-

Notes: Not present

- = not present; <25%; 25-50%; 50-75% >75%

Photo ☐

Sacrum (only record if sufficiently complete to assess normal curvature)

	Presence (%)	Abnormal Shape
Sacrum	-	-

Notes: Not present

Photo ☐

X-rays required (y/n) (indicate in notes which bones/elements to be radiographed)	☐
X-rays completed (y/n)	☐

Summary

Possible Vitamin D deficiency present?	Yes

Sex/Age Estimation Date: 19-May-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 347

Age Estimation – Juvenile

Dental Development (following Gustafson and Koch 1974)

Deciduous Dentition

Maxilla				
	Left	Right	Unsided 1	Unsided 2
m^2	4	4	-	-
m^1	4	4	-	-
c	4	4	-	-
i^2	4	4	-	-
i^1	-	-	-	-

Mandible				
	Left	Right	Unsided 1	Unsided 2
m_2	-	-	-	-
m_1	-	-	-	-
c	-	-	-	-
i_2	-	-	-	-
i_1	-	-	-	-

Permanent Dentition *

Maxilla				
	Left	Right	Unsided 1	Unsided 2
M^2	-	-	-	-
M^1	2.5	-	-	-
PM^2	-	2	-	-
PM^1	-	-	-	-
C	-	-	-	-
I^2	-	-	-	-
I^1	-	-	-	-

Mandible				
	Left	Right	Unsided 1	Unsided 2
M^2	-	-	-	-
M^1	-	-	-	-
PM^2	-	-	-	-
PM^1	-	-	-	-
C	-	-	-	-
I^2	-	-	-	-
I^1	-	-	-	-

Scoring: - = could not be assessed; 1 = start of mineralization; 1.5 = past start of mineralization, but not yet at complete crown; 2 = complete crown; 2.5 = crown complete, but not certain if eruption has occurred; 3 = eruption in progress; 3.5 eruption complete (teeth are in occlusion), but not certain if root is fully formed; 4 = eruption and root complete

*If M3s are present, record side & development here: Max _____ Max _____ Mand _____ Mand _____

Long Bone Length
(in mm)

	Left	Right
Femur	204	205
Tibia	160	160
Fibula	155	156
Humerus	155	
Radius	112	
Ulna	123	

Notes:

Epiphyseal Fusion (following Cardoso 2008 a, b) - Fusion should be scored on **left** bone only. If left is not present right should be scored.

Femur: 1 - proximal epiphysis; 2 – greater trochanter; 3 – lesser trochanter; 4 – distal epiphysis
Tibia: 1 – proximal epiphysis; 2 – distal epiphysis
Humerus: 1 – proximal epiphysis; 2 – distal epiphysis; 3 – medial epicondyle
Radius: 1 – proximal epiphysis; 2 – distal epiphysis
Pelvis: 1 – iliac crest; 2 – ischial epiphysis
Clavicle: 1 – sternal epiphysis

	Side	Epiphysis 1	Epiphysis 2	Epiphysis 3	Epiphysis 4
Femur	Left	1	1	1	1
Tibia	Left	1	1		
Humerus	Left	1	1	1	
Radius	Left	1	1		
Pelvis	Left	1	1		
Clavicle	Left	1			
Other	-	-	-	-	-

Scoring: - = could not be assessed; 1 = non-union (epiphysis and diaphysis are completely separate); 2 = partial union; 3 – complete union (all visible aspects of epiphysis are united)

Sex/Age Estimation Date: 19-May-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 347

Summary Information

Dental Dev. Age Estimate	Long Bone Length Age Estimate	Epiphyseal Fusion Age Estimate	Dental Wear Age Estimate (if applicable)
4.5-6 years	2.5-4 years	less than/equal to 14	

Notes:

Pars lateralis and pars basilaris not fused. Individual probably less than 5.
4-5 years old

Dental Wear (modified from Brothwell 1965) – for older adolescents and adults (M1 must be erupted and in occlusion)

Maxilla		
	Left	**Right**
M3	-	-
M2	-	-
M1	-	-

Mandible		
	Left	**Right**
M3	-	-
M2	-	-
M1	-	-

Modified scoring: - = could not be assessed; score - 1-13 (refer to diagram)

Notes:

Sex/Age Estimation Date: 19-May-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 347

Sex Estimation – Adult

Will not be attempted for those <16 years old. For those 16+ years the features of the skull/mandible and pelvis set out in Buikstra and Ubelaker (1994) will be used.

Pelvis		
	Left	**Right**
Ventral Arc (1-3) *	-	-
Subpubic Concavity (1-3) *	-	-
Ischiopubic Ramus Ridge (1-3) *	-	-
Greater Sciatic Notch (1-5) *	-	-
Preauricular Sulcus (1-4) *	-	-
Estimated Sex	Undetermined	

Skull		
	Left	**Right**
Nuchal Crest (1-5) *	-	
Mastoid Process (1-5) *	-	-
Supraorbital Margin (1-5) *	-	-
Glabella (1-5) *	-	
Mental Eminence (1-5) *	-	
Estimated Sex	Undetermined	

Notes:

In all cases (skull and pelvis) the left should be preferentially scored. When the left side is absent, the right can be scored.
* after observations described in Buikstra & Ubelaker 1994 (pp. 16-21):
0-3 scale: - (blank) = not observable; 1 = female; 2 = ambiguous; 3 = male
0-4 scale: - (blank) = no sulcus; 1 = sulcus is wide (>0.5cm) and deep; 2 = sulcus is wide but shallow; 3 = sulcus is well defined but narrow; 4 = sulcus is a narrow (<0.5cm), shallow, and smooth-walled depression.
0-5 scale: - (blank) = not observable; 1 = female; 2 = probable female; 3 = ambiguous; 4 = probable male; 5 = male

Age Estimation - Adult

Pubic Symphysis Scoring System (following Brooks and Suchey 1990; Suchey and Katz 1986)

	Left	**Right**
Phase	-	-

Notes:

Scoring: - = could not be assessed; phases 1-6 (see Buikstra and Ubelaker, 1994: 23-24)

Sex/Age Estimation Date: 19-May-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 347

Auricular Surface Scoring System – Transition Analysis (following Boldsen et al. 2002:101-103) (can record multiple stages for a single feature)[1]

	Left		Right	
	Min	Max	Min	Max
Superior Topography (1-3)	-	-	-	-
Inferior Topography (1-3)	-	-	-	-
Superior Characteristics (1-5)	-	-	-	-
Apical Characteristics (1-5)	-	-	-	-
Inferior Characteristics (1-5)	-	-	-	-
Inferior Texture (1-3)	-	-	-	-
Superior* Exostoses (1-6)	-	-	-	-
Inferior* Exostoses (1-6)	-	-	-	-
Posterior Exostoses (1-3)	-	-	-	-

Notes:

[1]Record the left auricular surface. When the left is absent, the right can be recorded but do not mix the two sides.
Scoring: - = could not be assessed; see Boldsen et al. 2002
* Superior and Inferior Posterior Iliac Crest

Summary Information – Adult Age and Sex

Age[1]	4-5 years
Sex[2]	

[1]Young adult (20-34), middle adult (35-49), old adult (50+)
[2]After Buikstra and Ubelaker (1994: 21): undetermined; female; probable female; ambiguous; probable male; male

Date: 20-May-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 347

Juvenile Pathology Form

Cranium

	Left			Right		
	Present/ Absent	Abnormal Porosity	Abnormal Shape	Present/ Absent	Abnormal Porosity	Abnormal Shape
Frontal	present	absent	absent	present	absent	absent
Orbital roof	present	absent	-	present	absent	-
Parietal	present	absent	-	present	absent	absent
Temporal	present	absent	absent	present	absent	absent
Maxilla	present		absent	present		absent
Mandibular ramus	absent		-	-		-
Other	-	-	-	-	-	-

	Unsided		
Occipital	present	absent	absent

Photo ☒

Notes: Right parietal, anterior to parietal boss is a small circular depression approximately 1cm diameter, indicative of blunt force trauma, Well healed.

Scoring: - = feature not observable; 0 = feature absent; 1 = feature present

Ribs

	# Left (1-12)	# Right (1-12)	# Unsided (1-24)	Abnormal Porosity[1]	Flaring[1]	Fractures[2]	Cupping[3]
Proximal Ends	12	10					
Costochondral Ends			16	0	5	0	5
Abnormal rib curvature*	-	-					

Notes: Very slight cupping and very slight thickening at 5 costochondral ends.

* can only be assessed on complete ribs

[1] - Only assessed at costochondral ends.

[2] – If fracture is located somewhere other than costochondral end, indicate location and side (if possible in notes section.

[3] – indicates the total number of ribs exhibiting cupping

Scoring: - = not observable; indicate number of ribs with pathology

Photo ☒

Date: 20-May-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 347

Long Bones – Presence[1]

Element	LEFT					RIGHT				
	Prox epip	Prox 1/3	Mid 1/3	Distal 1/3	Distal epip	Prox epip	Prox 1/3	Mid 1/3	Distal 1/3	Distal epip
Clavicle	-	>75%	>75%	>75%	>75%	<25%	>75%	>75%	>75%	>75%
Humerus	>75%	>75%	>75%	>75%	>75%	<25%	>75%	>75%	>75%	50-75%
Radius	>75%	>75%	>75%	>75%	<25%	>75%	50-75%	-	-	-
Ulna	>75%	>75%	>75%	>75%	50-75%	>75%	>75%	-	-	-
Femur	>75%	>75%	>75%	>75%	>75%	>75%	>75%	>75%	>75%	-
Tibia	>75%	>75%	>75%	>75%	>75%	>75%	>75%	>75%	>75%	>75%
Fibula	>75%	>75%	>75%	>75%	>75%	>75%	>75%	>75%	>75%	50-75%

* segment preservation: - = not present; <25%; 25-50%; 50-75% >75%

Long Bones – Pathology

	Abnormal Growth Plate	Thickening	Abnormal Shaft Shape	Abnormal Metaphysis Shape	Other (features such as fracture)*
LEFT Side					
Clavicle		absent	absent	absent	absent
Humerus	normal	absent	absent	absent	absent
Radius	1	absent	absent	absent	absent
Ulna	1	absent	absent	absent	absent
Femur	1	absent	present	absent	absent
Tibia	normal	absent	absent	absent	absent
Fibula	1	absent	absent	absent	absent

Notes: Very slight roughening on distal growth plates. Slight velvet texture on growth plates. Possible case.
Left femur slightly bowed in proximal third of diaphysis bending slightly anteriorly.
Photo of femur bowing, growth plates, rib flaring and cupping

*Provide details about 'other' pathological features in the notes box.

** Indicate which bones/elements photographed in notes box.

[1] n/a is to be used when the growth plate is fused. Only the distal growth plate is scored. Scoring adopted from Mays et al. 2006.

Photo** [X]

Date: 20-May-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 347

Long Bones (continued)

	Abnormal Growth Plate[1]	Thickening	Abnormal Shaft Shape	Abnormal Metaphysis Shape	Other (features such as fracture)*
RIGHT Side					
Clavicle		absent	absent	absent	absent
Humerus	1	absent	-	absent	absent
Radius	-	absent	-	absent	absent
Ulna	1	absent	absent	absent	absent
Femur	1	absent	absent	absent	absent
Tibia	1	absent	absent	absent	absent
Fibula	1	absent	absent	absent	absent
Notes: Very slight roughening on distal growth plates. Velvet texture.					

*Provide details about 'other' pathological features in the notes box.
** Indicate which bones/elements photographed in notes box.
[1] n/a is to be used when the growth plate is fused. Only the distal growth plate is scored. Scoring adopted from Mays et al. 2006.

Photo** ☒

Ilium (following Ortner and Brown 2011)

	Presence (%)	Abnormal Shape
Right ilium	>75%	absent
Left ilium	25-50%	-

Notes:

- = not present; <25%; 25-50%; 50-75% >75%

Photo ☐

Sacrum (only record if sufficiently complete to assess normal curvature)

	Presence (%)	Abnormal Shape
Sacrum	50-75%	-

Notes: Not fused

Photo ☐

X-rays required (y/n) (indicate in notes which bones/elements to be radiographed)	☐
X-rays completed (y/n)	☐

Summary

Possible Vitamin D deficiency present?	Yes

Sex/Age Estimation Date: 04-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 440

Age Estimation – Juvenile

Dental Development (following Gustafson and Koch 1974)

Deciduous Dentition

Maxilla	Left	Right	Unsided 1	Unsided 2
m^2	1	-	-	-
m^1	1	-	-	-
c	1	-	-	-
i^2	2	2	-	-
i^1	2	2	-	-

Mandible	Left	Right	Unsided 1	Unsided 2
m_2	1	1	-	-
m_1	1	1	-	-
c	1	1	-	-
i_2	2	2	-	-
i_1	2	2	-	-

Permanent Dentition

Maxilla	Left	Right	Unsided 1	Unsided 2
M^2	-	-	-	-
M^1	-	-	-	-
PM^2	-	-	-	-
PM^1	-	-	-	-
C	-	-	-	-
I^2	-	-	-	-
I^1	-	-	-	-

Mandible	Left	Right	Unsided 1	Unsided 2
M^2	-	-	-	-
M^1	-	-	-	-
PM^2	-	-	-	-
PM^1	-	-	-	-
C	-	-	-	-
I^2	-	-	-	-
I^1	-	-	-	-

Scoring: - = could not be assessed; 1 = start of mineralization; 1.5 = past start of mineralization, but not yet at complete crown; 2 = complete crown; 2.5 = crown complete, but not certain if eruption has occurred; 3 = eruption in progress; 3.5 eruption complete (teeth are in occlusion), but not certain if root is fully formed; 4 = eruption and root complete

If M3s are present, record side & development here: Max ____ Max ____ Mand ____ Mand _____

Long Bone Length (in mm)

	Left	Right
Femur	91	92
Tibia		
Fibula		
Humerus	77	
Radius		
Ulna		

Notes: One permanent canine in bag. Intrusive material.

Epiphyseal Fusion (following Cardoso 2008 a, b) - Fusion should be scored on **left** bone only. If left is not present right should be scored.

Femur: 1 - proximal epiphysis; 2 – greater trochanter; 3 – lesser trochanter; 4 – distal epiphysis
Tibia: 1 – proximal epiphysis; 2 – distal epiphysis
Humerus: 1 – proximal epiphysis; 2 – distal epiphysis; 3 – medial epicondyle
Radius: 1 – proximal epiphysis; 2 – distal epiphysis
Pelvis: 1 – iliac crest; 2 – ischial epiphysis
Clavicle: 1 – sternal epiphysis

	Side	Epiphysis 1	Epiphysis 2	Epiphysis 3	Epiphysis 4
Femur	left	1	1	1	1
Tibia	left	1	1		
Humerus	left	1	1	1	
Radius	left	1	1		
Pelvis	left	1	1		
Clavicle	left	1			
Other	-	-	-	-	-

Scoring: - = could not be assessed; 1 = non-union (epiphysis and diaphysis are completely separate); 2 = partial union; 3 – complete union (all visible aspects of epiphysis are united)

Sex/Age Estimation Date: 04-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 440

Summary Information

Dental Dev. Age Estimate	Long Bone Length Age Estimate	Epiphyseal Fusion Age Estimate	Dental Wear Age Estimate (if applicable)
2-4 mos	1.5-3 mos		
Notes:			

Dental Wear (modified from Brothwell 1965) – for older adolescents and adults (M1 must be erupted and in occlusion)

Maxilla		
	Left	**Right**
M3	-	-
M2	-	-
M1	-	-

Mandible		
	Left	**Right**
M3	-	-
M2	-	-
M1	-	-

Modified scoring: - = could not be assessed; score - 1-13 (refer to diagram)

Notes:

Sex/Age Estimation Date: 04-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 440

Sex Estimation – Adult

Will not be attempted for those <16 years old. For those 16+ years the features of the skull/mandible and pelvis set out in Buikstra and Ubelaker (1994) will be used.

Pelvis		
	Left	**Right**
Ventral Arc (1-3) *	-	-
Subpubic Concavity (1-3) *	-	-
Ischiopubic Ramus Ridge (1-3) *	-	-
Greater Sciatic Notch (1-5) *	-	-
Preauricular Sulcus (1-4) *	-	-
Estimated Sex	Undetermined	

Skull		
	Left	**Right**
Nuchal Crest (1-5) *	-	
Mastoid Process (1-5) *	-	-
Supraorbital Margin (1-5) *	-	-
Glabella (1-5) *	-	
Mental Eminence (1-5) *	-	
Estimated Sex	Undetermined	

Notes:

In all cases (skull and pelvis) the left should be preferentially scored. When the left side is absent, the right can be scored.
* after observations described in Buikstra & Ubelaker 1994 (pp. 16-21):
0-3 scale: - (blank) = not observable; 1 = female; 2 = ambiguous; 3 = male
0-4 scale: - (blank) = no sulcus; 1 = sulcus is wide (>0.5cm) and deep; 2 = sulcus is wide but shallow; 3 = sulcus is well defined but narrow; 4 = sulcus is a narrow (<0.5cm), shallow, and smooth-walled depression.
0-5 scale: - (blank) = not observable; 1 = female; 2 = probable female; 3 = ambiguous; 4 = probable male; 5 = male

Age Estimation - Adult

Pubic Symphysis Scoring System (following Brooks and Suchey 1990; Suchey and Katz 1986)

	Left	**Right**
Phase	-	-

Notes:

Scoring: - = could not be assessed; phases 1-6 (see Buikstra and Ubelaker, 1994: 23-24)

Sex/Age Estimation Date: 04-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 440

Auricular Surface Scoring System – Transition Analysis (following Boldsen et al. 2002:101-103) (can record multiple stages for a single feature)[1]

	Left		**Right**	
	Min	Max	Min	Max
Superior Topography (1-3)	-	-	-	-
Inferior Topography (1-3)	-	-	-	-
Superior Characteristics (1-5)	-	-	-	-
Apical Characteristics (1-5)	-	-	-	-
Inferior Characteristics (1-5)	-	-	-	-
Inferior Texture (1-3)	-	-	-	-
Superior* Exostoses (1-6)	-	-	-	-
Inferior* Exostoses (1-6)	-	-	-	-
Posterior Exostoses (1-3)	-	-	-	-

Notes:

[1]Record the left auricular surface. When the left is absent, the right can be recorded but do not mix the two sides.
Scoring: - = could not be assessed; see Boldsen et al. 2002
* Superior and Inferior Posterior Iliac Crest

Summary Information – Adult Age and Sex

Age[1]	2-4 mos
Sex[2]	

[1]Young adult (20-34), middle adult (35-49), old adult (50+)
[2]After Buikstra and Ubelaker (1994: 21): undetermined; female; probable female; ambiguous; probable male; male

Date: 04-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 440

Juvenile Pathology Form

Cranium

	Left			Right		
	Present/ Absent	Abnormal Porosity	Abnormal Shape	Present/ Absent	Abnormal Porosity	Abnormal Shape
Frontal	present	absent	absent	present	absent	absent
Orbital roof	present	absent	absent	present	absent	absent
Parietal	present	absent	absent	present	absent	absent
Temporal	present	absent	absent	present	absent	absent
Maxilla	present		present	absent		-
Mandibular ramus	absent		-	present		absent
Other	-	-	-	-	-	-

	Unsided		
Occipital	present	absent	absent

Photo ☐

Notes: Cranial vault has porosity, but seems to be related to baby bone growth.

Scoring: - = feature not observable; 0 = feature absent; 1 = feature present

Ribs

	# Left (1-12)	# Right (1-12)	# Unsided (1-24)	Abnormal Porosity[1]	Flaring[1]	Fractures[2]	Cupping[3]
Proximal Ends	7	6					
Costochondral Ends			7	-	3	-	-
Abnormal rib curvature*	-	-					

Notes: Thre ribs may have some slight flaring, but may be in range of normal.

* can only be assessed on complete ribs

[1] - Only assessed at costochondral ends.

[2] – If fracture is located somewhere other than costochondral end, indicate location and side (if possible in notes section.

[3] – indicates the total number of ribs exhibiting cupping

Scoring: - = not observable; indicate number of ribs with pathology

Photo ☒

Date: 04-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 440

Long Bones – Presence[1]

Element	LEFT					RIGHT				
	Prox epip	Prox 1/3	Mid 1/3	Distal 1/3	Distal epip	Prox epip	Prox 1/3	Mid 1/3	Distal 1/3	Distal epip
Clavicle	>75%	>75%	>75%	>75%	>75%	>75%	>75%	>75%	>75%	>75%
Humerus	25-50%	>75%	>75%	>75%	<25%	-	<25%	>75%	>75%	25-50%
Radius	<25%	>75%	>75%	>75%	>75%	-	-	-	-	-
Ulna	<25%	>75%	>75%	25-50%	-	-	-	-	-	-
Femur	50-75%	>75%	>75%	>75%	25-50%	25-50%	<25%	>75%	>75%	<25%
Tibia	25-50%	>75%	>75%	25-50%	-	25-50%	>75%	>75%	50-75%	-
Fibula	-	-	-	-	-	-	-	-	-	-

* segment preservation: - = not present; <25%; 25-50%; 50-75% >75%

Long Bones – Pathology

	Abnormal Growth Plate	Thickening	Abnormal Shaft Shape	Abnormal Metaphysis Shape	Other (features such as fracture)*
LEFT Side					
Clavicle		absent	absent	absent	absent
Humerus	-	absent	absent	absent	absent
Radius	-	absent	absent	absent	absent
Ulna	-	absent	absent	absent	absent
Femur	2	absent	absent	absent	absent
Tibia	2	absent	absent	absent	absent
Fibula	-	-	-	-	-

Notes: Distal growth plate are very porous. Difficult to know if it is due to pathology or taphonomy. Some of the proximal growth plates look similar, and some of the cortical bone has been eroded because of taphonomy in combination with less mineralized baby bone. I think the texture is more likely due to taphonomy. Bones do feel light. Radius may be slightly thickened near the midshaft and distal metaphysis.

*Provide details about 'other' pathological features in the notes box.

** Indicate which bones/elements photographed in notes box.

[1] n/a is to be used when the growth plate is fused. Only the distal growth plate is scored. Scoring adopted from Mays et al. 2006.

Photo** ☒

Date: 04-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 440

Long Bones (continued)

	Abnormal Growth Plate[1]	Thickening	Abnormal Shaft Shape	Abnormal Metaphysis Shape	Other (features such as fracture)*
RIGHT Side					
Clavicle		absent	absent	absent	absent
Humerus	2	absent	absent	absent	absent
Radius	-	-	-	-	-
Ulna	-	-	-	-	-
Femur	2	absent	absent	absent	absent
Tibia	-	absent	absent	absent	absent
Fibula	-	-	-	-	-
Notes: See above notes.					

*Provide details about 'other' pathological features in the notes box.

** Indicate which bones/elements photographed in notes box.

[1] n/a is to be used when the growth plate is fused. Only the distal growth plate is scored. Scoring adopted from Mays et al. 2006.

Photo** ☐

Ilium (following Ortner and Brown 2011)

	Presence (%)	Abnormal Shape
Right ilium	>75%	absent
Left ilium	>75%	absent

Notes:

Photo ☐

- = not present; <25%; 25-50%; 50-75% >75%

Sacrum (only record if sufficiently complete to assess normal curvature)

	Presence (%)	Abnormal Shape
Sacrum	-	-

Notes:

Photo ☐

X-rays required (y/n) (indicate in notes which bones/elements to be radiographed)	☐
X-rays completed (y/n)	☐

Summary

Possible Vitamin D deficiency present?	Yes

Sex/Age Estimation Date: 09-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 500

Age Estimation – Juvenile

Dental Development (following Gustafson and Koch 1974)

Deciduous Dentition

Maxilla	Left	Right	Unsided 1	Unsided 2
m^2	3.5	3.5	-	-
m^1	-	-	-	-
c	-	-	3.5	-
i^2	-	-	4	-
i^1	-	-	4	-

Mandible	Left	Right	Unsided 1	Unsided 2
m_2	-	-	-	-
m_1	-	-	-	-
c	-	-	-	-
i_2	-	-	-	-
i_1	-	-	-	-

Permanent Dentition

Maxilla	Left	Right	Unsided 1	Unsided 2
M^2	-	-	-	-
M^1	-	-	1.5	-
PM^2	-	-	-	-
PM^1	-	-	-	-
C	-	-	-	-
I^2	-	-	-	-
I^1	-	-	-	-

Mandible	Left	Right	Unsided 1	Unsided 2
M^2	-	-	-	-
M^1	-	-	-	-
PM^2	-	-	-	-
PM^1	-	-	-	-
C	-	-	-	-
I^2	-	-	-	-
I^1	-	-	-	-

Scoring: - = could not be assessed; 1 = start of mineralization; 1.5 = past start of mineralization, but not yet at complete crown; 2 = complete crown; 2.5 = crown complete, but not certain if eruption has occurred; 3 = eruption in progress; 3.5 eruption complete (teeth are in occlusion), but not certain if root is fully formed; 4 = eruption and root complete

If M3s are present, record side & development here: Max ____ Max ____ Mand ____ Mand _____

Long Bone Length
(in mm)

	Left	Right
Femur	143	
Tibia	117	117
Fibula		
Humerus		112
Radius		
Ulna		

Epiphyseal Fusion (following Cardoso 2008 a, b) - Fusion should be scored on **left** bone only. If left is not present right should be scored.

Femur: 1 - proximal epiphysis; 2 – greater trochanter; 3 – lesser trochanter; 4 – distal epiphysis
Tibia: 1 – proximal epiphysis; 2 – distal epiphysis
Humerus: 1 – proximal epiphysis; 2 – distal epiphysis; 3 – medial epicondyle
Radius: 1 – proximal epiphysis; 2 – distal epiphysis
Pelvis: 1 – iliac crest; 2 – ischial epiphysis
Clavicle: 1 – sternal epiphysis

	Side	Epiphysis 1	Epiphysis 2	Epiphysis 3	Epiphysis 4
Femur	left	1	1	1	1
Tibia	left	1	1		
Humerus	right	1	1	1	
Radius	-	-	-		
Pelvis	left	1	1		
Clavicle	left	1			
Other	-	-	-	-	-

Scoring: - = could not be assessed; 1 = non-union (epiphysis and diaphysis are completely separate); 2 = partial union; 3 – complete union (all visible aspects of epiphysis are united)

Notes:

Sex/Age Estimation Date: 09-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 500

Summary Information

Dental Dev. Age Estimate	Long Bone Length Age Estimate	Epiphyseal Fusion Age Estimate	Dental Wear Age Estimate (if applicable)
2-2.5 years	1-1.5 years	2-3 years	

Notes: All vertebral arches fused, but no bodies have fused.

Dental Wear (modified from Brothwell 1965) – for older adolescents and adults (M1 must be erupted and in occlusion)

Maxilla		
	Left	**Right**
M3	-	-
M2	-	-
M1	-	-

Mandible		
	Left	**Right**
M3	-	-
M2	-	-
M1	-	-

Modified scoring: - = could not be assessed; score - 1-13 (refer to diagram)

Notes:

Sex/Age Estimation Date: 09-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 500

Sex Estimation – Adult

Will not be attempted for those <16 years old. For those 16+ years the features of the skull/mandible and pelvis set out in Buikstra and Ubelaker (1994) will be used.

Pelvis	Left	Right
Ventral Arc (1-3) *	-	-
Subpubic Concavity (1-3) *	-	-
Ischiopubic Ramus Ridge (1-3) *	-	-
Greater Sciatic Notch (1-5) *	-	-
Preauricular Sulcus (1-4) *	-	-
Estimated Sex	Undetermined	

Skull	Left	Right
Nuchal Crest (1-5) *	-	
Mastoid Process (1-5) *	-	-
Supraorbital Margin (1-5) *	-	-
Glabella (1-5) *	-	
Mental Eminence (1-5) *	-	
Estimated Sex	Undetermined	

Notes:

In all cases (skull and pelvis) the left should be preferentially scored. When the left side is absent, the right can be scored.
* after observations described in Buikstra & Ubelaker 1994 (pp. 16-21):
0-3 scale: - (blank) = not observable; 1 = female; 2 = ambiguous; 3 = male
0-4 scale: - (blank) = no sulcus; 1 = sulcus is wide (>0.5cm) and deep; 2 = sulcus is wide but shallow; 3 = sulcus is well defined but narrow; 4 = sulcus is a narrow (<0.5cm), shallow, and smooth-walled depression.
0-5 scale: - (blank) = not observable; 1 = female; 2 = probable female; 3 = ambiguous; 4 = probable male; 5 = male

Age Estimation - Adult

Pubic Symphysis Scoring System (following Brooks and Suchey 1990; Suchey and Katz 1986)

	Left	Right
Phase	-	-

Notes:

Scoring: - = could not be assessed; phases 1-6 (see Buikstra and Ubelaker, 1994: 23-24)

Sex/Age Estimation Date: 09-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 500

Auricular Surface Scoring System – Transition Analysis (following Boldsen et al. 2002:101-103) (can record multiple stages for a single feature)[1]

	Left		Right	
	Min	Max	Min	Max
Superior Topography (1-3)	-	-	-	-
Inferior Topography (1-3)	-	-	-	-
Superior Characteristics (1-5)	-	-	-	-
Apical Characteristics (1-5)	-	-	-	-
Inferior Characteristics (1-5)	-	-	-	-
Inferior Texture (1-3)	-	-	-	-
Superior* Exostoses (1-6)	-	-	-	-
Inferior* Exostoses (1-6)	-	-	-	-
Posterior Exostoses (1-3)	-	-	-	-

Notes:

[1]Record the left auricular surface. When the left is absent, the right can be recorded but do not mix the two sides.
Scoring: - = could not be assessed; see Boldsen et al. 2002
* Superior and Inferior Posterior Iliac Crest

Summary Information – Adult Age and Sex

Age[1]	2-2.5 years
Sex[2]	

[1]Young adult (20-34), middle adult (35-49), old adult (50+)
[2]After Buikstra and Ubelaker (1994: 21): undetermined; female; probable female; ambiguous; probable male; male

Date: 09-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 500

Juvenile Pathology Form

Cranium

	Left			Right		
	Present/ Absent	Abnormal Porosity	Abnormal Shape	Present/ Absent	Abnormal Porosity	Abnormal Shape
Frontal	present	absent	absent	present	absent	absent
Orbital roof	present	absent	absent	present	absent	absent
Parietal	present	absent	absent	present	absent	absent
Temporal	present	absent	absent	present	absent	absent
Maxilla	absent		-	absent		-
Mandibular ramus	absent		-	absent		-
Other	-	-	-	-	-	-

	Unsided		
Occipital	present	absent	absent

Photo ☐

Notes:

Scoring: - = feature not observable; 0 = feature absent; 1 = feature present

Ribs

	# Left (1-12)	# Right (1-12)	# Unsided (1-24)	Abnormal Porosity[1]	Flaring[1]	Fractures[2]	Cupping[3]
Proximal Ends	10	3					
Costochondral Ends			1	-	-	-	-
Abnormal rib curvature*	-	-					

Notes:

* can only be assessed on complete ribs

[1] - Only assessed at costochondral ends.

[2] – If fracture is located somewhere other than costochondral end, indicate location and side (if possible in notes section.

[3] – indicates the total number of ribs exhibiting cupping

Scoring: - = not observable; indicate number of ribs with pathology

Photo ☐

Date: 09-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 500

Long Bones – Presence[1]

Element	LEFT					RIGHT				
	Prox epip	Prox 1/3	Mid 1/3	Distal 1/3	Distal epip	Prox epip	Prox 1/3	Mid 1/3	Distal 1/3	Distal epip
Clavicle	>75%	>75%	>75%	<25%	-	-	-	-	-	-
Humerus	<25%	>75%	>75%	>75%	50-75%	50-75%	>75%	>75%	>75%	<25%
Radius	-	50-75%	>75%	<25%	-	-	50-75%	>75%	<25%	-
Ulna	<25%	>75%	>75%	<25%	-	<25%	>75%	>75%	<25%	-
Femur	<25%	>75%	>75%	>75%	<25%	-	-	>75%	>75%	<25%
Tibia	>75%	>75%	>75%	>75%	50-75%	>75%	>75%	>75%	>75%	>75%
Fibula	-	>75%	>75%	>75%	50-75%	-	<25%	>75%	>75%	<25%

* segment preservation: - = not present; <25%; 25-50%; 50-75% >75%

Long Bones – Pathology

	Abnormal Growth Plate	Thickening	Abnormal Shaft Shape	Abnormal Metaphysis Shape	Other (features such as fracture)*
LEFT Side					
Clavicle		absent	absent	absent	absent
Humerus	normal	absent	absent	absent	absent
Radius	-	absent	absent	absent	absent
Ulna	-	absent	absent	absent	absent
Femur	normal	absent	absent	absent	absent
Tibia	normal	absent	absent	absent	absent
Fibula	normal	absent	present	absent	absent

Notes: Possible slight anterior bowing fibula.

*Provide details about 'other' pathological features in the notes box.

** Indicate which bones/elements photographed in notes box.

[1] n/a is to be used when the growth plate is fused. Only the distal growth plate is scored. Scoring adopted from Mays et al. 2006.

Photo** ☒

Date: 09-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 500

Long Bones (continued)

	Abnormal Growth Plate[1]	Thickening	Abnormal Shaft Shape	Abnormal Metaphysis Shape	Other (features such as fracture)*
RIGHT Side					
Clavicle		-	-	-	-
Humerus	normal	absent	absent	absent	absent
Radius	-	absent	absent	absent	absent
Ulna	-	absent	absent	absent	absent
Femur	normal	absent	absent	absent	absent
Tibia	normal	absent	absent	absent	absent
Fibula	normal	absent	present	absent	absent
Notes: Possible slight anterior bowing of the fibula.					

*Provide details about 'other' pathological features in the notes box.
** Indicate which bones/elements photographed in notes box.
[1] n/a is to be used when the growth plate is fused. Only the distal growth plate is scored. Scoring adopted from Mays et al. 2006.

Photo** ☐

Ilium (following Ortner and Brown 2011)

	Presence (%)	Abnormal Shape
Right ilium	-	-
Left ilium	50-75%	absent

Notes:

- = not present; <25%; 25-50%; 50-75% >75%

Photo ☐

Sacrum (only record if sufficiently complete to assess normal curvature)

	Presence (%)	Abnormal Shape
Sacrum	-	-

Notes:

Photo ☐

X-rays required (y/n) (indicate in notes which bones/elements to be radiographed)	☐
X-rays completed (y/n)	☐

Summary

Possible Vitamin D deficiency present?	Yes

Sex/Age Estimation Date: 17-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 542

Age Estimation – Juvenile

Dental Development (following Gustafson and Koch 1974)

Deciduous Dentition

Maxilla	Left	Right	Unsided 1	Unsided 2
m^2	1.5	1.5	-	-
m^1	3.5	3.5	-	-
c	2.5	2	-	-
i^2	3	3	-	-
i^1	3	3	-	-

Mandible	Left	Right	Unsided 1	Unsided 2
m_2	1.5	1.5	-	-
m_1	3	-	-	-
c	2.5	-	-	-
i_2	3	3	-	-
i_1	3	3	-	-

Permanent Dentition

Maxilla	Left	Right	Unsided 1	Unsided 2
M^2	-	-	-	-
M^1	1	1	-	-
PM^2	-	-	-	-
PM^1	-	-	-	-
C	-	-	-	-
I^2	-	-	-	-
I^1	-	-	-	-

Mandible	Left	Right	Unsided 1	Unsided 2
M^2	-	-	-	-
M^1	1	1	-	-
PM^2	-	-	-	-
PM^1	-	-	-	-
C	-	-	-	-
I^2	-	-	-	-
I^1	-	-	-	-

Scoring: - = could not be assessed; 1 = start of mineralization; 1.5 = past start of mineralization, but not yet at complete crown; 2 = complete crown; 2.5 = crown complete, but not certain if eruption has occurred; 3 = eruption in progress; 3.5 eruption complete (teeth are in occlusion), but not certain if root is fully formed; 4 = eruption and root complete

If M3s are present, record side & development here: Max ____ Max ____ Mand ____ Mand _____

Long Bone Length (in mm)

	Left	Right
Femur	127	127
Tibia		101
Fibula		
Humerus	102	102
Radius		72
Ulna		82

Notes:

Epiphyseal Fusion (following Cardoso 2008 a, b) - Fusion should be scored on **left** bone only. If left is not present right should be scored.

Femur: 1 - proximal epiphysis; 2 – greater trochanter; 3 – lesser trochanter; 4 – distal epiphysis
Tibia: 1 – proximal epiphysis; 2 – distal epiphysis
Humerus: 1 – proximal epiphysis; 2 – distal epiphysis; 3 – medial epicondyle
Radius: 1 – proximal epiphysis; 2 – distal epiphysis
Pelvis: 1 – iliac crest; 2 – ischial epiphysis
Clavicle: 1 – sternal epiphysis

	Side	Epiphysis 1	Epiphysis 2	Epiphysis 3	Epiphysis 4
Femur	left	1	1	1	1
Tibia	right	1	1		
Humerus	right	1	1	1	
Radius	right	1	1		
Pelvis	left	1	1		
Clavicle	left	1			
Other	-	-	-	-	-

Scoring: - = could not be assessed; 1 = non-union (epiphysis and diaphysis are completely separate); 2 = partial union; 3 – complete union (all visible aspects of epiphysis are united)

Sex/Age Estimation Date: 17-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 542

Summary Information

Dental Dev. Age Estimate	Long Bone Length Age Estimate	Epiphyseal Fusion Age Estimate	Dental Wear Age Estimate (if applicable)
12-18 mos	.5 years - 1 year	1-2 years	

Notes: Vertebral arches fused, mandible fusing together. Pars lateralis not fused to squamous portion

Dental Wear (modified from Brothwell 1965) – for older adolescents and adults (M1 must be erupted and in occlusion)

Maxilla		
	Left	**Right**
M3	-	-
M2	-	-
M1	-	-

Mandible		
	Left	**Right**
M3	-	-
M2	-	-
M1	-	-

Modified scoring: - = could not be assessed; score - 1-13 (refer to diagram)

Notes:

Sex/Age Estimation Date: 17-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 542

Sex Estimation – Adult

Will not be attempted for those <16 years old. For those 16+ years the features of the skull/mandible and pelvis set out in Buikstra and Ubelaker (1994) will be used.

Pelvis	Left	Right
Ventral Arc (1-3) *	-	-
Subpubic Concavity (1-3) *	-	-
Ischiopubic Ramus Ridge (1-3) *	-	-
Greater Sciatic Notch (1-5) *	-	-
Preauricular Sulcus (1-4) *	-	-
Estimated Sex	Undetermined	

Skull	Left	Right
Nuchal Crest (1-5) *	-	
Mastoid Process (1-5) *	-	-
Supraorbital Margin (1-5) *	-	-
Glabella (1-5) *	-	
Mental Eminence (1-5) *	-	
Estimated Sex	Undetermined	

Notes:

In all cases (skull and pelvis) the left should be preferentially scored. When the left side is absent, the right can be scored.
* after observations described in Buikstra & Ubelaker 1994 (pp. 16-21):
0-3 scale: - (blank) = not observable; 1 = female; 2 = ambiguous; 3 = male
0-4 scale: - (blank) = no sulcus; 1 = sulcus is wide (>0.5cm) and deep; 2 = sulcus is wide but shallow; 3 = sulcus is well defined but narrow; 4 = sulcus is a narrow (<0.5cm), shallow, and smooth-walled depression.
0-5 scale: - (blank) = not observable; 1 = female; 2 = probable female; 3 = ambiguous; 4 = probable male; 5 = male

Age Estimation - Adult

Pubic Symphysis Scoring System (following Brooks and Suchey 1990; Suchey and Katz 1986)

	Left	Right
Phase	-	-

Notes:

Scoring: - = could not be assessed; phases 1-6 (see Buikstra and Ubelaker, 1994: 23-24)

Sex/Age Estimation Date: 17-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 542

Auricular Surface Scoring System – Transition Analysis (following Boldsen et al. 2002:101-103) (can record multiple stages for a single feature)[1]

	Left		Right	
	Min	Max	Min	Max
Superior Topography (1-3)	-	-	-	-
Inferior Topography (1-3)	-	-	-	-
Superior Characteristics (1-5)	-	-	-	-
Apical Characteristics (1-5)	-	-	-	-
Inferior Characteristics (1-5)	-	-	-	-
Inferior Texture (1-3)	-	-	-	-
Superior* Exostoses (1-6)	-	-	-	-
Inferior* Exostoses (1-6)	-	-	-	-
Posterior Exostoses (1-3)	-	-	-	-

Notes:

[1]Record the left auricular surface. When the left is absent, the right can be recorded but do not mix the two sides.
Scoring: - = could not be assessed; see Boldsen et al. 2002
* Superior and Inferior Posterior Iliac Crest

Summary Information – Adult Age and Sex

Age[1]	1 - 1.5 years
Sex[2]	

[1]Young adult (20-34), middle adult (35-49), old adult (50+)
[2]After Buikstra and Ubelaker (1994: 21): undetermined; female; probable female; ambiguous; probable male; male

Date: 17-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 542

Juvenile Pathology Form

Cranium

	Left			Right		
	Present/ Absent	Abnormal Porosity	Abnormal Shape	Present/ Absent	Abnormal Porosity	Abnormal Shape
Frontal	absent	-	-	absent	-	-
Orbital roof	absent	-	-	absent	-	-
Parietal	present	absent	absent	present	absent	absent
Temporal	present	absent	absent	present	absent	absent
Maxilla	present		absent	present		absent
Mandibular ramus	present		absent	present		absent
Other	-	-	-	-	-	-

	Unsided		
Occipital	present	absent	absent

Photo ☐

Notes:

Scoring: - = feature not observable; 0 = feature absent; 1 = feature present

Ribs

	# Left (1-12)	# Right (1-12)	# Unsided (1-24)	Abnormal Porosity[1]	Flaring[1]	Fractures[2]	Cupping[3]
Proximal Ends	2	2					
Costochondral Ends			4	-	-	-	-
Abnormal rib curvature*	-	-					

Notes: 4 ribs are thickened near the sternal ends - refer to Ortner and Mays 1998
Possibly acute curvature of first right rib.

* can only be assessed on complete ribs
[1] - Only assessed at costochondral ends.
[2] – If fracture is located somewhere other than costochondral end, indicate location and side (if possible in notes section.
[3] – indicates the total number of ribs exhibiting cupping
Scoring: - = not observable; indicate number of ribs with pathology

Photo ☒

Date: 17-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 542

Long Bones – Presence[1]

Element	LEFT					RIGHT				
	Prox epip	**Prox 1/3**	**Mid 1/3**	**Distal 1/3**	**Distal epip**	**Prox epip**	**Prox 1/3**	**Mid 1/3**	**Distal 1/3**	**Distal epip**
Clavicle	<25%	>75%	>75%	>75%	>75%	>75%	<25%	-	-	-
Humerus	<25%	>75%	>75%	>75%	-	25-50%	>75%	>75%	>75%	25-50%
Radius	-	<25%	>75%	<25%	-	<25%	>75%	>75%	>75%	<25%
Ulna	-	>75%	>75%	50-75%	-	50-75%	>75%	>75%	>75%	<25%
Femur	<25%	>75%	>75%	>75%	<25%	25-50%	>75%	>75%	>75%	50-75%
Tibia	25-50%	>75%	>75%	>75%	-	25-50%	>75%	>75%	>75%	25-50%
Fibula	-	-	-	-	-	-	-	-	-	-

* segment preservation: - = not present; <25%; 25-50%; 50-75% >75%

Long Bones – Pathology

	Abnormal Growth Plate	**Thickening**	**Abnormal Shaft Shape**	**Abnormal Metaphysis Shape**	**Other (features such as fracture)***
LEFT Side					
Clavicle		absent	absent	absent	absent
Humerus	normal	absent	absent	absent	absent
Radius	-	absent	absent	absent	absent
Ulna	-	absent	absent	absent	absent
Femur	1	absent	present	present	absent
Tibia	-	absent	present	absent	absent
Fibula	-	-	-	-	-

Notes: Anterior bowing of the diaphysis of the tibia, and possibly the femur. The femur may also have distal metaphyseal flaring. The distal growth plate looks like velvet.
The tibia shows a depostition of porous bone in the concavity of the bowing very similar to the example in Mays et al. 2006.

*Provide details about 'other' pathological features in the notes box.

** Indicate which bones/elements photographed in notes box.

[1] n/a is to be used when the growth plate is fused. Only the distal growth plate is scored. Scoring adopted from Mays et al. 2006.

Photo** ☒

Date: 17-Jun-2015 Site Lisieux-Michelet

Observer: Sarah Timmins Sk # 542

Long Bones (continued)

	Abnormal Growth Plate[1]	Thickening	Abnormal Shaft Shape	Abnormal Metaphysis Shape	Other (features such as fracture)*
RIGHT Side					
Clavicle		absent	absent	absent	absent
Humerus	normal	absent	absent	absent	absent
Radius	normal	present	absent	absent	absent
Ulna	normal	absent	absent	absent	absent
Femur	1	absent	present	present	absent
Tibia	normal	absent	present	absent	absent
Fibula	-	-	-	-	-

Notes: Anterior bowing of the diaphysis of the tibia, and possibly the femur. The femur may also have distal metaphyseal flaring. The distal growth plate looks like velvet.
The tibia shows a deposition of porous bone in the concavity of the bowing. The radius may also show thickening along the distal portion of the diaphysis.

*Provide details about ‘other’ pathological features in the notes box.

** Indicate which bones/elements photographed in notes box.

[1] n/a is to be used when the growth plate is fused. Only the distal growth plate is scored. Scoring adopted from Mays et al. 2006.

Photo** ☒

Ilium (following Ortner and Brown 2011)

	Presence (%)	Abnormal Shape
Right ilium	>75%	absent
Left ilium	>75%	absent

Notes:

- = not present; <25%; 25-50%; 50-75% >75%

Photo ☐

Sacrum (only record if sufficiently complete to assess normal curvature)

	Presence (%)	Abnormal Shape
Sacrum	<25%	-

Notes:

Photo ☐

X-rays required (y/n) (indicate in notes which bones/elements to be radiographed)	☐
X-rays completed (y/n)	☐

Summary

Possible Vitamin D deficiency present?	Yes

Sex/Age Estimation Date: June 19, 2015 Site Lisieux-Michelet

Observer: Lisa Sk # 713

Age Estimation – Juvenile

Dental Development (following Gustafson and Koch 1974)

Deciduous Dentition

Maxilla	Left	Right	Unsided 1	Unsided 2
m^2	-	-	-	-
m^1	-	-	-	-
c	-	-	-	-
i^2	-	-	-	-
i^1	-	-	-	-

Mandible	Left	Right	Unsided 1	Unsided 2
m_2	-	-	-	-
m_1	-	-	-	-
c	-	-	-	-
i_2	-	-	-	-
i_1	-	-	-	-

Permanent Dentition

Maxilla	Left	Right	Unsided 1	Unsided 2
M^2	-	-	-	-
M^1	-	-	-	-
PM^2	4	-	-	-
PM^1	4	-	-	-
C	-	-	-	-
I^2	-	-	-	-
I^1	-	-	-	-

Mandible	Left	Right	Unsided 1	Unsided 2
M^2	-	3.5	-	-
M^1	-	-	-	-
PM^2	-	-	4	-
PM^1	-	-	4	-
C	-	-	-	-
I^2	4	4	-	-
I^1	4	4	-	-

Scoring: - = could not be assessed; 1 = start of mineralization; 1.5 = past start of mineralization, but not yet at complete crown; 2 = complete crown; 2.5 = crown complete, but not certain if eruption has occurred; 3 = eruption in progress; 3.5 eruption complete (teeth are in occlusion), but not certain if root is fully formed; 4 = eruption and root complete

If M3s are present, record side & development here: Max 1.5 Max ____ Mand ____ Mand ____

Long Bone Length (in mm)

	Left	Right
Femur		372
Tibia	310	
Fibula		
Humerus		
Radius	200	
Ulna		

Notes: Other = proximal ulna. Dens of C2 complete. Lateral segments of sacrum unfused.

Epiphyseal Fusion (following Cardoso 2008 a, b) - Fusion should be scored on **left** bone only. If left is not present right should be scored.

Femur: 1 - proximal epiphysis; 2 – greater trochanter; 3 – lesser trochanter; 4 – distal epiphysis
Tibia: 1 – proximal epiphysis; 2 – distal epiphysis
Humerus: 1 – proximal epiphysis; 2 – distal epiphysis; 3 – medial epicondyle
Radius: 1 – proximal epiphysis; 2 – distal epiphysis
Pelvis: 1 – iliac crest; 2 – ischial epiphysis
Clavicle: 1 – sternal epiphysis

	Side	Epiphysis 1	Epiphysis 2	Epiphysis 3	Epiphysis 4
Femur	left	1	1	1	1
Tibia	left	1	1		
Humerus	left	1	3	1	
Radius	left	1	1		
Pelvis	left	1	1		
Clavicle	left	1			
Other	left	2	-	-	-

Scoring: - = could not be assessed; 1 = non-union (epiphysis and diaphysis are completely separate); 2 = partial union; 3 – complete union (all visible aspects of epiphysis are united)

Sex/Age Estimation Date: June 19, 2015 Site Lisieux-Michelet

Observer: Lisa Sk # 713

Summary Information

Dental Dev. Age Estimate	Long Bone Length Age Estimate	Epiphyseal Fusion Age Estimate	Dental Wear Age Estimate (if applicable)
11-14 years	10.5-12 years	12-13 years	
Notes:			

Dental Wear (modified from Brothwell 1965) – for older adolescents and adults (M1 must be erupted and in occlusion)

Maxilla		
	Left	**Right**
M3	-	-
M2	-	-
M1	-	-

Mandible		
	Left	**Right**
M3	-	-
M2	-	-
M1	-	-

Modified scoring: - = could not be assessed; score - 1-13 (refer to diagram)

Notes:

Sex/Age Estimation Date: June 19, 2015 Site Lisieux-Michelet

Observer: Lisa Sk # 713

Sex Estimation – Adult

Will not be attempted for those <16 years old. For those 16+ years the features of the skull/mandible and pelvis set out in Buikstra and Ubelaker (1994) will be used.

Pelvis	Left	Right
Ventral Arc (1-3) *	-	-
Subpubic Concavity (1-3) *	-	-
Ischiopubic Ramus Ridge (1-3) *	-	-
Greater Sciatic Notch (1-5) *	-	-
Preauricular Sulcus (1-4) *	-	-
Estimated Sex	Undeterminec	

Skull	Left	Right
Nuchal Crest (1-5) *	-	
Mastoid Process (1-5) *	-	-
Supraorbital Margin (1-5) *	-	-
Glabella (1-5) *	-	
Mental Eminence (1-5) *	-	
Estimated Sex	Undeterminec	

Notes:

In all cases (skull and pelvis) the left should be preferentially scored. When the left side is absent, the right can be scored.
* after observations described in Buikstra & Ubelaker 1994 (pp. 16-21):
0-3 scale: - (blank) = not observable; 1 = female; 2 = ambiguous; 3 = male
0-4 scale: - (blank) = no sulcus; 1 = sulcus is wide (>0.5cm) and deep; 2 = sulcus is wide but shallow; 3 = sulcus is well defined but narrow; 4 = sulcus is a narrow (<0.5cm), shallow, and smooth-walled depression.
0-5 scale: - (blank) = not observable; 1 = female; 2 = probable female; 3 = ambiguous; 4 = probable male; 5 = male

Age Estimation - Adult

Pubic Symphysis Scoring System (following Brooks and Suchey 1990; Suchey and Katz 1986)

	Left	Right
Phase	-	-

Notes:

Scoring: - = could not be assessed; phases 1-6 (see Buikstra and Ubelaker, 1994: 23-24)

Sex/Age Estimation Date: June 19, 2015 Site Lisieux-Michelet

Observer: Lisa Sk # 713

Auricular Surface Scoring System – Transition Analysis (following Boldsen et al. 2002:101-103) (can record multiple stages for a single feature)[1]

	Left		Right	
	Min	Max	Min	Max
Superior Topography (1-3)	-	-	-	-
Inferior Topography (1-3)	-	-	-	-
Superior Characteristics (1-5)	-	-	-	-
Apical Characteristics (1-5)	-	-	-	-
Inferior Characteristics (1-5)	-	-	-	-
Inferior Texture (1-3)	-	-	-	-
Superior* Exostoses (1-6)	-	-	-	-
Inferior* Exostoses (1-6)	-	-	-	-
Posterior Exostoses (1-3)	-	-	-	-

Notes:

[1]Record the left auricular surface. When the left is absent, the right can be recorded but do not mix the two sides.
Scoring: - = could not be assessed; see Boldsen et al. 2002
* Superior and Inferior Posterior Iliac Crest

Summary Information – Adult Age and Sex

Age[1]	11-13 years
Sex[2]	Undetermined

[1]Young adult (20-34), middle adult (35-49), old adult (50+)
[2]After Buikstra and Ubelaker (1994: 21): undetermined; female; probable female; ambiguous; probable male; male

Date: 19-Jun-2015 Site Lisieux-Michelet

Observer: Lisa Sk # 713

Juvenile Pathology Form

Cranium

	Left			Right		
	Present/ Absent	Abnormal Porosity	Abnormal Shape	Present/ Absent	Abnormal Porosity	Abnormal Shape
Frontal	absent	-	-	absent	-	-
Orbital roof	absent	-	-	absent	-	-
Parietal	absent	-	-	absent	-	-
Temporal	absent	-	-	absent	-	-
Maxilla	absent		-	absent		-
Mandibular ramus	present		absent	absent		-
Other	-	-	-	-	-	-

	Unsided		
Occipital	present	absent	absent

Photo

Notes:

Scoring: - = feature not observable; 0 = feature absent; 1 = feature present

Ribs

	# Left (1-12)	# Right (1-12)	# Unsided (1-24)	Abnormal Porosity[1]	Flaring[1]	Fractures[2]	Cupping[3]
Proximal Ends	9	9					
Costochondral Ends			-	-	-	-	-
Abnormal rib curvature*	0	0					

Notes:

* can only be assessed on complete ribs

[1] - Only assessed at costochondral ends.

[2] – If fracture is located somewhere other than costochondral end, indicate location and side (if possible in notes section.

[3] – indicates the total number of ribs exhibiting cupping

Scoring: - = not observable; indicate number of ribs with pathology

Photo

Date: 19-Jun-2015 Site Lisieux-Michelet

Observer: Lisa Sk # 713

Long Bones – Presence[1]

Element	LEFT					RIGHT				
	Prox epip	Prox 1/3	Mid 1/3	Distal 1/3	Distal epip	Prox epip	Prox 1/3	Mid 1/3	Distal 1/3	Distal epip
Clavicle	>75%	>75%	>75%	>75%	-	-	-	<25%	<25%	-
Humerus	>75%	>75%	>75%	>75%	>75%	-	-	-	>75%	-
Radius	>75%	>75%	>75%	>75%	>75%	-	<25%	50-75%	-	-
Ulna	>75%	>75%	>75%	>75%	25-50%	>75%	>75%	>75%	>75%	>75%
Femur	>75%	>75%	>75%	>75%	>75%	>75%	>75%	>75%	>75%	>75%
Tibia	>75%	>75%	>75%	>75%	>75%	50-75%	>75%	>75%	>75%	-
Fibula	>75%	>75%	>75%	25-50%	-	-	>75%	>75%	>75%	25-50%

* segment preservation: - = not present; <25%; 25-50%; 50-75% >75%

Long Bones – Pathology

	Abnormal Growth Plate	Thickening	Abnormal Shaft Shape	Abnormal Metaphysis Shape	Other (features such as fracture)*
LEFT Side					
Clavicle		absent	absent	absent	absent
Humerus	normal	absent	absent	absent	absent
Radius	normal	absent	present	absent	absent
Ulna	normal	absent	absent	absent	absent
Femur	normal	absent	present	present	absent
Tibia	normal	absent	absent	absent	absent
Fibula	-	absent	absent	-	absent

Notes: Abnormal curvature of radial shaft - slight posterior bowing of the middle 1/3 (photo). Abnormal curvature and flaring of the metaphysis in the femur (photo).

*Provide details about 'other' pathological features in the notes box.

** Indicate which bones/elements photographed in notes box.

[1] n/a is to be used when the growth plate is fused. Only the distal growth plate is scored. Scoring adopted from Mays et al. 2006.

Photo** ☐

Date: 19-Jun-2015 Site Lisieux-Michelet

Observer: Lisa Sk # 713

Long Bones (continued)

	Abnormal Growth Plate[1]	Thickening	Abnormal Shaft Shape	Abnormal Metaphysis Shape	Other (features such as fracture)*
RIGHT Side					
Clavicle		absent	absent	-	absent
Humerus	-	absent	absent	-	absent
Radius	-	absent	absent	-	absent
Ulna	-	absent	absent	-	absent
Femur	normal	absent	present	absent	absent
Tibia	normal	absent	absent	-	absent
Fibula	normal	absent	absent	absent	absent
Notes: Abnormal curvature of femur (photo).					

*Provide details about 'other' pathological features in the notes box.

** Indicate which bones/elements photographed in notes box.

[1] n/a is to be used when the growth plate is fused. Only the distal growth plate is scored. Scoring adopted from Mays et al. 2006.

Photo** ☐

Ilium (following Ortner and Brown 2011)

	Presence (%)	Abnormal Shape
Right ilium	>75%	absent
Left ilium	>75%	absent

Notes:

- = not present; <25%; 25-50%; 50-75% >75%

Photo ☐

Sacrum (only record if sufficiently complete to assess normal curvature)

	Presence (%)	Abnormal Shape
Sacrum	25-50%	-

Notes:

Photo ☐

X-rays required (y/n) (indicate in notes which bones/elements to be radiographed)	☐
X-rays completed (y/n)	☐

Summary

Possible Vitamin D deficiency present?	Yes