Charnel Deposits from St Bartlemas' Chapel Excavation, Oxford 2011

Discussion of the Palaeopathology and its Implications

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Introduction

This report serves as an addendum to the Preliminary Assessment of the Human Remains by Paula Levick assisted by Ceri Boston of Oxford Archaeology. It focuses solely on the human remains from the charnel deposits, the cemetery soils and the drain and soakaway. The intact burials, which were not recovered, do not feature in the present examination. Pathology was studied in greater detail than in the former report and some observations are made on the demographic and metrical aspects of the osteology.

Leprosy

Leprosy is still a huge problem in the developing world today with the World Health Organisation estimating that there were 1.8 million cases worldwide in 1995 (McDougall 1996). In countries where leprosy is still rife, it tends to affect one in 100 people (Rawcliffe 2006) so its infectivity is quite low. A vigorous campaign to wipe out leprosy was carried out from 1982 onwards. In fact, during 1993-4, 3.8 million cases were detected and successfully treated (Joshi 2010). This was made possible by the initiation of a treatment regime involving multidrug therapy in the 1970s.

Young people are particularly vulnerable to contracting the disease between the ages of 10 and 20 but the bony changes take from 5 – 7 years to develop. In England and Wales, the disease had a very limited temporal span, only reaching endemic proportions between the 12th and 14th centuries (Clay 1909). There were around 1100 medieval hospitals at their apogee, about a quarter of which were specifically for sufferers from leprosy (Magilton 2008; Knowles and Hadcock 1971). The chief building period for such hospitals was before the middle of the thirteenth century (Clay 1909). During the fourteenth century, schemes of taxation still made reference to lepers and measures were taken for their expulsion from towns. Like other hospitals, leprosaria were situated outside the city walls, which made it easier for sufferers from the disease to respect the interdiction they were under not to enter the urban precinct. This medieval view of the leper as being 'unclean' is based on a biblical quotation from Leviticus (Chapter 13 verse 46):

> "All the days wherein the plague shall be in him he shall be defiled; he is unclean; he shall dwell alone; without the camp shall his habitation be."

Isolation in a hospital only came into force once facial changes had become very obvious, so there may have been many people suffering from less obvious forms of the disease who were at large in the community. Those with advanced disease who were not fortunate enough to be

offered sanctuary in a leprosarium were forced to roam the highways with their bell or clapper and beg for alms.

History of the disease in England

Received wisdom states that leprosy was brought back by Crusaders returning from Palestine in the 11th century. However, the archaeological record suggests otherwise. The earliest cases of leprosy in England were seen in the Romano-British period at Cirencester (Wells 1982) and at Poundbury (Reader, 1974). Four cases were detected at the Iron Age site of Cannington (Brothwell 2000) which was near a port – often a place where early evidence of a new disease is found. During Anglo-Saxon times, sporadic cases have been identified, e.g. at Beckford, Gloucester (Wells 1996) and at Edix Hill in Cambridgeshire (Duhig 1998). The Saxo-Norman site of St John, Timberhill, Norwich produced between 24 and 35 cases of leprosy (Anderson 1998). The largest cemetery from a leprosy hospital to have been excavated up to the present comes from medieval Chichester where 384 burials were excavated at the Hospital of St James and St Mary Magdalene (Lee and Magilton 2008). Seventy-five of these (19.5%) showed osteological evidence of the disease (Lee and Manchester 2008) and a further ten had bone changes which suggest that this was these 75 were the tip of a larger iceberg (Storm, pers comm). An ongoing excavation of the medieval leprosarium in the City of Winchester is producing the entire range of buildings, including the chapel (Roffey, pers comm), and a good proportion of the burials excavated so far have the distinctive facial and other changes to indicate that they suffered from advanced leprosy, which has been confirmed by the DNA evidence. The advent of the Black Death in the middle of the fourteenth century halved the population of England (Miller and Hatcher 1978) and may have been partly responsible for the banishing of the disease to remote regions of the south-west and Scotland. Those who were left alive enjoyed a better standard of living (Dyer 1989) and leprosy is known to be a disease of poverty. It lingered in Scandinavia well into the 19th century, long enough for the bacterium to be identified by Hansen in 1873.

The medieval view of leprosy

Leprosy hospitals were quasi-monastic institutions which were run by a warden. The inmates were expected to lead increasingly disciplined lives in order to be purged of their sins, which were considered to be the cause of their disease. However, it was also thought that their sufferings represented purgatory on earth which would enable them to pass straight into heaven (Magilton 2008).The link with Lazarus whom Jesus cured was responsible for this more benign view. Indeed Queen Matilda, the wife of Henry I founder of St Bartlemas' hospital, associated with the leprous rather in the way that Princess Diana did with sufferers from AIDS and is even thought to have kissed the feet of some sufferers.

Legally, they were not permitted to plead a case nor bequeath or inherit property, which after their deaths became the possession of the institution. It was a state of being dead unto the world but alive unto God (Palmer 1982). Sufferers from leprosy even underwent the 'Rite of Sarum', as part of which they stood in a grave and some soil was poured over their heads or feet. The association between putrid flesh and the physical manifestations of leprosy was thought to be important in this respect (Morgan 1999).

Paradoxically, the elderly and infirm also sought admission to leprosaria which after the 14th century often became almshouses for "poor impotent folk". In another twist to the tale, as times became harder in the thirteenth century, those who could pay might be given preferential admittance over the infirm (Satchell 1998).

The leper

"*The leper wears a sombre gown and cape tightly closed; a hood conceals his want of hair which is, however, betrayed by the absence of eyebrows and lashes; his limbs are maimed and stunted so that he can but hobble or crawl; his features are ulcerated and sunken; his staring eyes are unseeing and unsightly; his wasted lips part and a husky voice entreats help as he extends supplicating lazar arms with bell and clapper dish*." (Clay 1909: 48).

Clinical aspects of leprosy

Leprosy is a bacterial infection caused by the organism *Mycobacterium leprae*. The word 'leprosy' comes from the Greek 'lepros'. It predominantly affects the skin and nerves. In fact, it is the only such condition which causes nerve damage in the sufferer and this is what makes the physical manifestations so unpleasant (Malaviya 2010). Like other chronic granulomatous infections such as tuberculosis, it is the response of the patient's immune system which is the cause of tissue damage as much as the disease itself. This is particularly true of tuberculoid leprosy, which is the type seen in those with the most powerful immune reaction. This causes milder skin lesions with fewer bacteria than other forms of leprosy but very rapid onset of peripheral nerve damage (Malaviya 2010) due to the cell-mediated response.

At the other end of the spectrum lepromatous leprosy, seen in those who have a poor immune response, produces severe changes to the skin and mucous membranes which are full of bacilli. The characteristic facial features are wrinkling and thickening of the skin (known as leonine facies), disappearance of facial hair and eyebrows and paralysis of the lower eyelid termed lagophthalmos (Shah and Shah 2010). As the disease progresses the nasal spine and cartilage are affected, leading to a sunken nose. Bacteria in the swollen mucous membranes cause nasal congestion and a purulent discharge (Malaviya 2010).

The nerves of the postcranial skeleton become thickened and replaced by fibrous tissue and gradually both sensory, and then motor, function are affected. It is the unopposed action of normal muscles that leads to instability in the joints. Damage to the sensory nerve leads to a condition termed 'glove and stocking' anaesthesia when the peripheral nerves of the forearm or lower leg are affected.

The leprosarium at St Bartlemas' chapel

St Bartlemas or St Bartholomew's Hospital is situated at Cowley Marsh, about a mile from east gate of Oxford in 1126 (Satchell 1998). It was one of the first group of 16 such leprosaria to be founded, shortly after the first two at Rochester and Harbledown. The latter hospital is characteristic of such foundations being composed of a group of cottages and a chapel surrounding a green, often with a well in the centre (Clay 1909). St Bartlemas, Oxford is thought to have been similar in plan to the precinct of St James' Hospital, Winchester,

which was composed of a free-standing chapel perpendicular to the master's house and parallel to a range of individual rooms for the inmates. Sixteen leper hospitals situated mainly in the south of England took the name of the apostle St Bartholomew. This was due to the saint's perceived medical powers remembered as follows "lepers he cleanses, the sick he restores". It is also thought to be linked with the way in which he was martyred by being flayed alive (Rawcliffe 2006). There is an obvious association with skin diseases, which is reinforced by the fact that a piece of his skin was one of the relics preserved at the leprosarium and later acquired by Oriel College as a source of revenue.

The situation of the hospital was particularly suitable for obtaining alms from travellers, since it was located beside one of the main routes to the city. Lepers are last mentioned as residing at the hospital in the Will of John de Vintner dated 1342 (Satchell 1998). Fourteen years earlier, Edward II had granted the institution to Oriel College because the last three Masters had been either corrupt or incompetent. As a Royal hospital it would have been administered by the Chancellor of the Exchequer. Originally it was intended to house 12 sick persons and a chaplain (Knowles and Hadcock 1971: 383; Page 1907: 157). Moreover, because of the Charter, some inmates would have been former royal servants from outside the area (Satchell 1998). Grants of money from King Henry I were generous by the standards of the day and provided 1d per day for each inmate, in addition to a clothing allowance from the Oxford revenues of 65s per year.

Two cartloads of hay came from the Royal meadow at Oseney each year. The land surrounding the hospital extended to six acres and some inmates were responsible for cultivating it, growing cereals, rye and barley. They kept doves and raised livestock, most likely cattle. Land was also made available in Stanton St John and Cowley since the hospital was part of the Royal Manor of Headington. King Henry II is known to have paid £10 10s 4d for repairs to the buildings and Henry III granted timber to the house, a demonstration of continuing royal interest. However, by 1250 the standard of living enjoyed by those inhabiting the leprosarium had declined somewhat and, as with many such institutions the numbers gradually dwindled. In 1316, the number of inhabitants had reduced to eight brethren, of whom two should be healthy in order to carry out work on the farm. The brothers were "under a rule, wore a habit and had to be unmarried" (Knowles and Hadcock 971: 383). In 1326, the wardenship was granted to Adam de Brome, Provost of Oriel and after that sick members of the college could also retire there (Page 1907).

Bone changes of leprosy

Leprosy mainly affects three areas of the body: the nasal region, hands and feet, with secondary involvement of the lower legs and occasionally also the forearm. There are three mechanisms by which the disease can cause damage to the extremities. The first involves *M. Leprae* bacteria circulating in the bloodstream and setting up infection in the bones leading to very characteristic changes in their shape and possible osteomyelitis (Andersen *et al* 1994). In addition, by affecting the sensory and motor nerve supply to the hands and feet, claw hand, drop foot and ultimately alterations to the longitudinal and transverse arches of the foot

occur. Damage to the peripheral nerves in the feet produces loss of sensation and makes it more likely that the individual will injure themselves. Consequently, ulceration develops particularly beneath the first and fifth metatarsals (Andersen *et al* 1992). There are also alterations to the blood vessels which are important factors in the bone changes.

People with leprosy may have poor eyesight because of paralysis of the lower eyelid, termed *lagophthalmos*, which can lead to infection of the eyes. Even if they can see their hands and thus avoid injury to them, it is likely that they will be unaware of trauma to the soles of their feet.

The bone changes are quite characteristic of leprosy and do not occur in those with paralysis of the extremities due to nerve damage from other causes (Andersen *et al* 1992). As a result, it is possible to be certain that an individual was suffering from the disease if the bony changes mentioned in the following paragraphs are present but not if periostitis of the tibia and fibula are not accompanied by foot lesions.

Changes to the nasal region

Rhinomaxillary change is only found in those with the most severe form of the disease, lepromatous leprosy (Manchester 2008). The main alterations are resorption of the nasal spine with remodelling of that area, rounding of the normally sharp nasal aperture, particularly around its inferior aspect and symmetrical resorption of the alveolar bone in the upper jaw so that the front teeth and canines may become loose in their sockets and ultimately fall out (Andersen and Manchester 1992). There may also be porosity of the palatine bone both on its superior surface which forms the floor of the nasal aperture and also palatine process of the maxilla which is beneath the soft tissues of the roof of the mouth. In extreme cases the thin bone can perforate centrally, meaning that food will have access to the nasal cavity. Manchester (2011) had developed a grading system so that the severity of rhinomaxillary change can be compared between populations.

Maxillary sinusitis is a considerable problem in leprosy sufferers and results from the entire maxilla becoming infected, with bony changes to the floors of the maxillary sinuses and also their posterior surfaces in many cases.

At Bartlemas Chapel, there were no leprous changes to the only maxilla found in the charnel pits (Context 1015/19). Although this individual was edentulous, the rim of the nasal aperture was sharp and the resorption of the maxilla resulted from antemortem loss of all teeth and the resulting resorption of alveolar bone in the entire jaw (Figure 1). However, there were two upper jaws which did exhibit the facial changes of leprosy within the cemetery soils. The first was found in Context 1016 from the grave fill of Sk 1 in Trench 1. This was a left maxilla with both premolars and the first two molars intact (Figure 2). The central incisor and third molar had probably been lost shortly before the individual died but the sockets for the lateral incisor and canine remained in the jaw. The margin of the alveolar bone above the tooth sockets was rounded, indicating an advanced degree of periodontal disease and the gingival tissues had undoubtedly become inflamed owing to the calculus, or mineralised plaque, on the buccal surface of the first molar. This tooth showed evidence of trauma which had

occurred during life and a large piece had broken away from the lingual surface of the molar. The edge of the break had become smoothed, indicating that it was an antemortem process.

The nasal aperture itself showed a complete absence of all the normal internal structures, including the turbinate bones. This represents Manchester's grade 3, which is the most severe. The palatine bone had become very thin and porous. There was evidence of bony resorption internally near the superior margin of the nasal aperture.

The other maxilla showing evidence of leprosy was found in Context 3002 from Trench 2. This was a fragment of left maxilla containing both premolars but having lost both incisors antemortem (Figure 3). There was also rounding of the nasal aperture and extreme resorption of the alveolar bone in the region of the incisors. The socket for the canine remained. Considerable porosity was seen on both the nasal and palatine surfaces of the maxilla. This maxilla also fell into the most severe category.

Bone changes to the hands in leprosy

The main changes to the bones result from claw hand deformity caused by loss of sensation due to nerve damage. The ulnar nerve becomes thickened and can be felt protruding at the elbow joint. In severe cases the median nerve is also affected and this can lead to a 'swan-neck' deformity of the fingers (Malaviya 2010). This can cause depressions near the tips of the phalanges on their palmar surfaces or varying degrees of destruction of the phalanges. Changes rarely proceed beyond the metacarpo-phalangeal joint so it is the digits that are mainly affected (Andersen *et al* 1994), by contrast any of the joints in the feet may be affected. There were no hand bones from Bartlemas Chapel with signs of leprosy.

Bone changes to the feet in leprosy

Damage to the joints of the toes may result from both loss of sensation in the feet and bacteria circulating in the bloodstream and causing granulomas to form close to the joints (Malaviya 2010). The trabecular bone is thinned causing it to become fragile and osteoporotic. Ulceration of the soles may lead to septic arthritis in the joints, particularly those between the metatarsals and phalanges. However, it can also cause damage to, or ankylosis of, the tarsal bones and spread of the infection to the bones of the lower leg (Andersen *et al* 1992). Infection in the joints of the metatarsals and phalanges or septic arthritis leads to healing of the bones in strange positions and also 'knife-edge' remodelling with resorption of the bone of the metatarsal shafts externally and narrowing of the medulla on X-ray.

At Bartlemas Chapel there were three foot bones from Charnel Pit 2 (Sk3) which showed definite evidence of leprosy. They probably came from the same foot. The first metatarso-phalangeal joint showed septic arthritis and the proximal phalanx had been resorbed until only a small cap remained (Figures 4a and b). This had fused to the metatarsal shaft which was extremely porous, indicating inflammatory change. Another metatarsal exhibited porosity of its entire shaft and a third demonstrated knife-edge remodelling and narrowing at the distal end (the so-called 'sucked candy' appearance).

Non-specific infection of the lower limb bones

The term 'periostitis' implies inflammation affecting the surface of the bone beneath the periosteal membrane, which may be due to infection or other causes such as trauma. Where the periosteal reaction is distributed symmetrically on the bones of both legs one may suspect that a specific infection such as leprosy or treponemal disease have been the cause. In the former, the distribution of the periosteal reaction is often very characteristic, creating a smooth, undulating layer of new bone on adjacent surfaces of the tibia and fibula (Manchester 2008). Pairing of some of the bones from the charnel pits had been possible in some cases (Levick 2012). Indeed the tibiae from Context 1015/5 showed evidence of a severe periosteal reaction affecting both bones (Figure 5). Other bones from Charnel Pit 2 with similar changes were a left tibia (Context 1007 – Figure 6), a right fibula (1015/16) and fibula shaft fragments (1015/17 – Figure 7). A fibula from Trench 1(1049) displayed a severe periosteal reaction and an individual aged 16-18 from Charnel Pit 3 had a smooth swelling of both tibiae and the right humerus, probably also due to infection.

The bacteria causing the inflammation are normally staphylococci which have gained entry as a result of injury to the feet and the infection spreads up the lower leg along the interosseous membrane, as far as the knee joint.

Rickets

In order to develop normally, the human skeleton needs adequate supplies of vitamin D. This is required to maintain levels of calcium and phosphate in the blood, which is essential for mineralisation of bone (Shenkin 1992). Up to 80% of vitamin D can be provided by sunlight (Reid 1992) so an inadequate diet is not the disaster it might seem to be (Brickley 2000). This is probably the reason that rickets is seldom seen in rural England during the medieval period, despite regular episodes of famine. It was during the transition from a rural to an urban industrialised economy that child health began to be compromised by conditions such as rickets and scurvy (Lewis 2000).

Rickets was first named as such in England early in the 17th century by a Dutchman, Daniel Whistler (Beck 1997). A detailed description of its clinical signs in infants was published by Francis Glisson in AD 1650. The volume was then translated from the Latin the following year (Glisson 1651). This represented a comprehensive study by a committee of the Royal College of Physicians into this mysterious affliction. In fact, it has been described as "the outstanding disease of the 17th century" (Radbill 1974) since it was correctly identified as a nutritional disease, given a name and included in Paediatric textbooks henceforward.

At the time, a lot of blame was laid at the door of nurses, both wet nurses and the nannying kind, because the group who appeared to be affected most were the children of the nobility. Nurses were blamed for trying to stand young children on their feet too early, thus causing the bones of their lower limbs and shoulders to become bowed (Glisson 1651).

Galen's theory of the four humours still governed medical thinking in England at the time and English medicine had not changed much since Roman times. However, it was recognised

that the supply of nutrients to the bones in rickets was inadequate, which Glisson attributed to deficiencies in the blood supply to various anatomical elements. He thought this caused one side of the bone to grow faster than the other (Beck 1997). He also noted swellings at the wrists and ankles, in addition to beading at the sternal ends of the ribs and a narrow chest shaped like a chicken's breast. He described the difficulty and pain that severely vitamin-deficient children experienced in developing and using their teeth, which sometimes became blackened and fell out, thus conflating the problems of rickets and scurvy.

Fildes, in 1986, studied the historical aspects of rickets and highlighted the fact that wet nurses frequently took on too many babies to nurse in succession, which probably affected their own vitamin supplies. The children of wealthy parents were often excessively swaddled and not allowed to play out in the sunshine as much as the children of the poor. Whereas in the 17th century the children of the well-to-do most often contracted rickets, in 19th century England industrialisation led to mothers working in factories and being able to breast feed for a shorter time as a result. Rickets consequently became a disease of the urban poor; narrow streets and a smoky atmosphere produced the right conditions for young children to become deprived of sunlight and so their supplies of vitamin D became depleted.

Rickets occurs in early life when there is inadequate mineralisation of osteoid in bone (Shenkin 1992). The age of 9 – 18 months seems to be when infants are most susceptible (Fildes 1986) but most of them recover by the age of two to three years. However, the curvature in their leg bones remains and for this reason healed rickets is the most common finding in adults. However, in extreme cases of vitamin D deficiency the pelvis can become misshapen, making childbirth hazardous. Osteomalacia is the term for changes that occur in adulthood usually in the shoulder blade, spine or pelvis.

At St Bartlemas, rickets was seen in it healed state in both legs of an adult from context 1026 in Charnel Pit 1, which was situated at the north side of the chapel. The femora and tibiae were severely bowed (Figures 8 and 9) and circular holes had been drilled in both ends of all four bones suggesting they had been mounted as an anatomical specimen before being discarded and buried in the pit (Levick 2012). This individual was assessed as female on metric grounds.

Charnel deposits

Charnel pit 1 appears to have been associated with the rebuilding of the chapel in the mid 17th century during the English Civil War. However, it is something of a mystery why an anatomical specimen should have found its way into this particular deposit. Charnel pits were the preferred method for dealing with an overcrowded graveyard in medieval England. Those digging a new plot would be forced to remove the bones of a person previously buried there, in order to accommodate the new inmate. There appeared to be no religious reason for abhorring this practice, since the body would be reconstituted at the Day of Judgement (Horrox 1999). Nevertheless, because of the risk of disturbance, after 1399 61% of Wills requested burial within the church. At postmedieval sites, particularly in hospital precincts, anatomical specimens are often buried as a means of disposal once they are no longer required (Fowler and Powers 2012).

Anatomical dissection

Dissections were first performed at Oxford University in 1549 (Sawday 1995: 56) during the reign of Edward VI, when his Visitation of the University began (Sinclair and Robb-Smith 1950). It was laid down by statute that medical students had to attend two 'anatomies' during their six-year training period and doctors studying for their MD two to three. However, there is scant written evidence that this statute was fulfilled initially (Valadez 1974), apart from Walter Bayley, the Regius Professor, who left to his son-in-law in his Will a 'skeliton of bones in Oxford'. This may have been either a teaching aid or simply a curiosity. In 1624, the first public anatomical dissection took place. Indeed, during the 17th century these events were almost theatrical and drew members of the public in a way that seems strange at the present time (Sawday 1995). In the same year, the Tomlins Readership in Anatomy was established. Indeed, Oxford was the first university in Britain to endow an academic post in the discipline. The Lecturer was paid £25 per year by Tomlin to demonstrate the anatomy and he, in his turn, paid a surgeon £3 per year to perform the actual dissection and prepare the body (Valadez 1974). A further forty shillings was allowed for collection and "decent burial of the body and all necessaries thereunto" (Sinclair and Robb-Smith 1950: 12). The main candidates for dissection were members of the criminal class who had been sentenced to death and hanged. "A Sounde body of one of the Executed persons" was procured at the Lent Assizes (Sinclair and Robb-Smith 1950). In addition, the Great Charter of Charles I decreed that any person executed within 21 miles round Oxford should be made available.

Dissections happened within a day or two of death because there was no way of preserving the body; they certainly could not take place in summer (Sawday 1995). Both men and women were hanged, the latter often for killing an illegitimate child. There were no assizes in the Michaelmas, or autumn, term but the Reader would give a lecture in Osteology then or at other times of year at the Anatomy School in the Bodleian Library (Sinclair and Robb-Smith 1950). One is recorded on 3 December 1632, and for this presumably a prepared and mounted skeleton would be necessary to demonstrate anatomical or pathological features. The reader would discuss "the skeleton or History of the bones with theire Situation Nature and Office" (Sinclair and Robb-Smith 1950: 12). In 1634, one Thomas Trapham is recorded as having prepared a skeleton at Oxford for use in anatomy teaching (Valadez 1974). Furthermore, in 1654 the writer John Evelyn recorded seeing "two skeletons which are finely cleansed and put together" in the library at St John's College (Sinclair and Robb-Smith 1950:14).

Defleshing and drilling of the bones would have been necessary to produce a mounted specimen. The practice of disembowelling a corpse and defleshing it by boiling the bones has a long history (Horrox 1999). When an individual died far from home, on a military campaign such as the Crusades for example, they would need to be repatriated. It was customary to remove the viscera and bury them where the individual had fallen for hygienic reasons. In addition, his heart might be returned to a particular place which had been important to him for burial. This was a custom which was stopped by Pope Boniface in 1399 but it demonstrates that such techniques for cleaning and defleshing the body were known at an early date. By the same token, when anatomy demonstrations took place on fresh skeletons

in Oxford, there were four lectures over two days. The first of these would deal with the "liver, spleene, stomacke and guttes" because these were the organs which deteriorated most quickly after death.

Interestingly, there is a link between Francis Glisson, who studied rickets so intensively, and Joyliffe, the discoverer of the lymphatic system. Joyliffe was trained in Oxford probably by Thomas Clayton, the first Tomlin Reader in Anatomy, and was known as "that dexterous Dissector" (Sinclair and Robb-Smith 1950: 13). Joyliffe later met Glisson at Cambridge and Glisson subsequently (in 1652) records learning about the lymphatic system from Joyliffe (Valadez 1974). It naturally follows that the subject of rickets, which was the new disease of the 17th century (Radbill 1974), should have been of great interest to those who were teaching medical students in Oxford at the time. Taking into account the growing awareness of the skeletal manifestations of rickets, in conjunction with an increasing interest in anatomy, it is probably not surprising that the lower limbs of the woman from context 1026 ended up in the dissecting room and lecture theatre, only to find their way into the charnel pit at St Bartlemas' chapel once they were no longer required.

After 1651, with the departure of Dr Petty to join Cromwell's army in Ireland, anatomical teaching was neglected in Oxford and students complained that they were given animals to dissect instead of humans (Valadez 1974). However, during the second half of the 16th century the anatomical research flourished in the city with the work of Willis on the brain, Lower on the heart and lungs and Harvey on the circulation.

Further evidence for the use of prisoners in dissection was found during the excavations at Oxford Castle (Keys 2004). A total of 60-70 burials were recovered, dating to the 16th – 18th centuries. Several of these individual had undergone post-mortem processes such as sawing through the cranium. They had not received a Christian burial in consecrated ground but had been eventually consigned to the moat. Removal of the top of the cranium is seen in an illustration from the *Corporis Humani Disquisitio Anatomica* published by Nathaniel Highmore of Trinity College, Oxford in 1651.

Joint disease

There was remarkably little evidence for joint disease, which is one of the most common categories in palaeopathology. Osteoarthritis of the right acromioclavicular joint in context 1026/12 probably resulted from an old injury to the shoulder since there was some ossification of the joint capsule. This can be caused by a fall, if the landing is awkward. Otherwise there was slight degenerative change to the knee joints of the invidual from context 1015/1, who had marginal osteophytosis of both femoral condyles, and a very small patch of eburnation on the femoral side of the knee joint in context 1000F. Such minor deterioration of the joints is normally age-related.

Musculoskeletal markers of stress

In order to retain its normal shape, the human skeleton requires fairly constant activity. Disuse of a particular limb results in rapid loss of both muscle and bone substance, as anyone who has had a bone in plaster for a period knows. Similarly, activities performed regularly

exert stress on muscle insertions and bone is laid down in these areas, which are known as musculoskeletal stress markers or 'enthesopathies'. Hawkey and Merbs (1995) studied Hudson Bay Eskimos who are known to have strong responses to this kind of stress, in the arms particularly, and quantified differences between the sexes. At Bartlemas, the robust male femora (1015/3a and b) demonstrated enthesopathies of the tendons which insert on the linea aspera, mainly the adductors. Similar changes were seen on the very robust femur from context 1034/1. As far as the upper limbs were concerned, there was a slight biceps enthesopathy on the right radius from context 3000 and for deltoid on the left clavicle from 1026/11. There was also a large cortical defect at the deltoid insertion on the robust left humeral fragment from the Soakaway (context 1054). These depressions represent extreme stress on a tendon in young adulthood.

Those living in the medieval leprosarium would have tended the garden and performed agricultural tasks when they were well enough so one might have expected to find more evidence of stress markers in this group.

Bone modification

Evidence of gnawing by animals was seen in two contexts: the left humerus from 1007 demonstrated canid gnawing at proximal end of the shaft and five score marks from rodent gnawing in the region of the deltoid insertion. In context 1015/3 there was evidence of canid gnawing around the a femoral head fragment from the left femur. The presence of such modification suggests that bones were lying on or near the surface for some time, since it does not occur on buried bones which are more likely to show insect damage. All the modified bones came from Charnel Pit two.

Discussion

In spite of the relatively small amount of human bone derived from the charnel pits, a great deal of information has been gleaned which throws light on the use of the area surrounding Bartlemas Chapel. Firstly, there is a considerable difference in the evidence for infection when the bones from Charnel Pit 1 and Charnel Pit 2 are compared. The former, which dates from the later use of the area, has very little sign of infection on the bones of the lower limbs. Evidence for periostitis of the tibia and fibula are slight. By contrast, in Charnel Pit 2 almost all the long bones from the lower legs show considerable infective change with the characteristic distribution pattern of secondary infection from leprosy. The bones from the drain to the east of the chapel also show increased amounts of compact bone on their surfaces. The adolescent individual from Charnel Pit 3 also showed thickening of some long bones suggestive of non-specific infection.

Gender differences between the charnel pits are instructive. Most of the measurements taken from long bones in Charnel Pit 1 fell into the female range, whereas all of those in Charnel Pit 2 which could be measured were from males or probable males (Levick 2012). This is due to the fact that Charnel Pit 2 contains bones from the early period when the chapel served the leprosarium. St Bartlemas' Hospital was founded for a chaplain/warden and 12 sick persons, later reduced to eight brethren and the master; female benefactresses and nurses were occasionally buried in leprosy hospitals (Lee and Magilton, 2008) but this does not appear to

have been the case in the Oxford establishment, as far as one can judge from this small sample. Living height ranged from just under five feet for the female with rickets in Charnel Pit 1 to six feet for the male in Charnel Pit 2. He was at the upper end of the range for late medieval male stature; the tallest male at Chichester was 6ft 2ins. By contrast, the stature of the individual with rickets was equivalent to the shortest female at Chichester (Lee and Magilton, 2008) but the bowing of her lower limbs would have reduced her height quite considerably.

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