Chapter 3: Analyses of the Human Skeletons

INTRODUCTION

Following their excavation and recovery from the grave the human skeletal remains were carefully cleaned and packaged according to IFA (McKinley and Roberts 1993) and UKIC guidelines (1983; 1985) before undergoing osteological examination. The primary aims of the osteological examination were to explore the number of individuals present, the demographic profile of the group, their health and physical attributes and the nature and extent of trauma. Attempts to re-associate crania ('skulls') with infra-cranial skeletons (torso and limbs, termed 'skeletons' hereon) were largely unsuccessful (but see the section on re-association, below) and therefore the skulls and associated cervical vertebrae are considered first, followed by the infra-cranial skeletons. The separation of these elements is logical because this is the way in which they had been deposited within the grave, with the heads deposited separately from the rest of the body (see Chapter 2).

After the osteological examination had been completed, bones and teeth were sampled and analysed isotopically in order to explore the geographic origins, migratory histories and diets of the individuals. The results of this work, and the osteology, are detailed in the following sections and discussed further in Chapter 5.

METHODOLOGY

All skeletal remains were examined in accordance with national guidelines (Hillson 1996; Brickley and McKinley 2004; Mays *et al*. 2002). This involved scoring bone condition, fragmentation and completeness; assessment of ancestry, biological sex and age; estimation of stature; the calculation of skeletal indices; non-metrical assessment and recording of pathology and trauma.

Bone condition was classified according to the criteria in Table 3.1 (after McKinley 2004, 16) and levels of fragmentation, as either 'high' (most bones are fragmented), 'medium' (moderate fragmentation) or 'low' (slight fragmentation). In order to determine the degree of completeness, skulls were broken down into 32 separate elements and completeness was calculated as a percentage. Left and right orbits and maxillary sinuses were counted as separate elements, as were the left and right mandible. The term 'anterior mandible' has only been used for the discussion of trauma. For the skeletons, completeness was indicated by assigning them to one of four categories: 0-25%, 26-50%, 51-75%, 76-100%.

Ancestry, defined here as "….the biogeographic population to which a particular individual belongs, by virtue of their genetic heritage" (Barker *et al*. 2008, 322), was considered by visual assessment of craniofacial traits (after Buikstra and Ubelaker 1994; Gill 1986; 2001) and by metrical analysis applied to the formula and associated software programme CRANID (Wright 2008). Visual assessment categorises skulls as being either of 'white', 'black', 'east asian', 'american indian', or of 'mixed' ancestry. The CRANID package achieves broad geographic classifications for crania (for example, European and east Mediterranean) by automated multivariate comparison of 29 measurements with those of some 3,000 crania from around the world (Wright 2008).

Table 3.1 Criteria employed to score skeletal condition (after McKinley 2004, 16)

Score	*Criteria*
0	Surface morphology clearly visible with fresh appearance to bone and no modification
1	Slight and patchy surface erosion
2	More extensive erosion of surface
3	Most of the bone surface affected by some degree of erosion, general morphology maintained but detail of parts of surface masked by erosive action
4	All of bone surface affected by erosive action; general profile maintained and depth of modification not uniform across the whole surface
5	Heavy erosion across whole surface, completely masking normal surface morphology with some modification of profile.
5+	As for Grade 5 with extensive penetrating erosion resulting in modification of profile (includes near destroyed bone)

Biological sex was estimated by examining standard features of the skull (Ferembach *et al*. 1980; Buikstra and Ubelaker 1994; Schwartz 1995) and, for skeletons, the pelvis (Phenice 1969). The dimensions of joints, in particular femoral and humeral heads, were also employed as secondary indicators of sex. Skeletons were recorded as male, probable male (male?) or indeterminate depending on the degree of sexual dimorphism of features. Age estimates were assigned to the skulls by observing dental attrition (Miles 1962; Brothwell 1981, 72), cranial suture closure (Meindl and Lovejoy 1985), dental eruption and development (Van Beek 1983), arachnoid granulations (Barber 1997), fusion of the spheno-occipital synchondrosis (Scheuer and Black 2000, 114) and the maturity of cervical vertebrae (Cardoso and Ríos 2011, 239). Cranial suture closure was only used as a secondary indicator of age because it is widely considered to be unreliable (for example, see Key *et al.* 1994; Cox 2000; Lynnerup and Jacobsen 2003). Epiphyseal fusion (Scheuer and Black 2000), pubic symphyses (Brooks and Suchey 1990) and auricular surfaces (Lovejoy *et al.* 1985; Buckberry and Chamberlain 2002) were employed to estimate the ages of skeletons. Final determinations of age employed multiple indicators, balanced against the accepted reliability of the method concerned (as described by Meindl and Russell 1998, 375–399). Ageing using dental attrition indicators was considered particularly problematic, and the implications of this are considered below. For the purposes of analysis, the final age determinations were employed to assign each skeleton to one of the age categories listed in in Table 3.2.

Measurements were taken (where possible) and used in the estimation of stature by applying them to the appropriate regression formulae set out by Trotter and Gleser (1952; 1958) and revised by Trotter (1970). Skeletal indices were calculated to explore variation in the physical attributes of the population and employed the formulae given in Bass (1987). The presence or absence of frequently recorded non-metrical traits was scored with reference to Berry and Berry (1967); Finnegan (1978); Schwartz (1995) and Hillson (1996).

Table 3.2 Age categories employed in the analyses

Age range	*Age category*
13–17 years	Adolescent
18–25 years	Young adult
26-35 years	Prime adult
36-45 years	Mature adult
45+ years	Older adult
60+ years	Much older adult
< 18 years (not further defined)	Subadult
> 18 years (not further defined)	Adult

Evidence for dental disease and ante-mortem skeletal pathology and trauma was recorded and differential diagnoses explored, with reference to standard texts and backed up by radiological investigation (where relevant). Radiological surveys were limited to a few cases only, because routine surveys were beyond the scope of the project. Skeletal conditions were classified according to their preferred diagnosis as either congenital and developmental, metabolic; joint disease; ante-mortem trauma, or miscellaneous (diagnosis uncertain). The extent and range of pathology was explored by calculating both crude prevalence rates (number of individuals with a condition out of the total number of individuals observed: CPR) and true prevalence rates (number of elements or teeth with a particular condition out of the number of elements or teeth observed: TPR).

Recording peri-mortem trauma

Peri-mortem trauma is an insult to the body occurring around the time of death. It was diagnosed based on the principle that bone that has an intact organic matrix ('green bone') will respond differently to fracturing, compared with bone that has a partial organic matrix ('dry bone') (Raul *et al.* 2008; Loe 2009). Thus, green bone fractures are identified by their sharp, smooth margins, radiating fracture lines and fracture lines that are straight. Irregular fracture margins (or splintering), fragments that tend to stay attached to one another (or hinging), peeling or lifting of fracture margins, bending and margins that are usually discoloured, or the same colour as the surrounding bone, may also indicate peri-mortem trauma (Berryman and Haun 1996; Brothwell 1981; Kanze and Grossschmidt 2005). In addition, Knüsel and Outram (2006, 255) describe 'spalling', or the removal of chips of cortical bone in association with a peri-mortem parry fracture.

Additional criteria for identifying green bone fractures refer to taphonomic signatures on surrounding bone surfaces (Barker *et al.* 2008 a & b; Raul *et al*. 2008) and, for long bones, fracture margin texture, fracture angle (created by the fracture surface and the cortical surface) and fracture outline (in relation to the longitudinal axis) (Knüsel and Outram 2006; Villa and Mahieu 1991). Dry bone fractures may be distinguished from green bone fractures because they result in smaller and more regular fragments and have margins that are rough, uneven and (often) discontinuous (Kanze and Grossschmidt 2005; Sauer 1998).

All peri-mortem lesions were described with reference to their location (giving anatomical landmark and using directional terminology, such as posterior, anterior, etc.), their size, shape in plan, appearance and texture of margins and orientation. Only sharp force trauma was observed on the material. This refers to penetrating injuries (complete or incomplete) caused by a sharp edged instrument. All of the injuries were described with reference to the criteria set out by Byers (2005, 340-341), Kimmerle and Baraybar (2008, 268) and Reichs (1998). These refer to shape (whether straight or irregular), cross-sectional appearance (for example, 'v' or 'u' shaped), surface texture (smooth or serrated), depth, and presence of associated fractures (including hinge fractures), crushing or hilt. The presence of striations on the walls of the defect and evidence for bone wastage were also noted.

Injuries were further classified as either: cuts (or incisions); chops; peeling or shaved defects; scoops; point insertions or notched defects; slot fractures (Byers 2005; Kimmerle and Baraybar 2008; see Table 3.3). These reflect differences in force and angle of the insult and assist in identifying the attributes of the causative instrument. For example, chops are associated with a heavy force and may cause complete or incomplete fractures that are broad and have a width that is similar to their depth. Cuts are associated with lighter injuries that result when a sharp instrument is drawn across the bone surface, rather than through it, causing narrow, fine striations. They may also result from a forceful stabbing action (Byers 2005, 343).

Table 3.3 Classifications of sharp force defects employed in the present analysis (based on Byers 2005, 340-341; Kimmerle and Baraybar 2008, 284; and Reichs 1998)

Sharp force defect	*Features*
Cuts or incisions	Fine, linear, striations that usually have 'v' shaped cross-sections. Usually caused by sharp instruments drawn across the cortical surface of bone. Vary in width – very thin or strongly 'v' shaped. Dimensions vary depending on size of instrument, amount of energy delivering it and size of bone (among other factors). Generally, long instruments contacting bone over a large area will cause long incisions; short instruments contacting bone over a small section will cause short incisions. Thickness depends on instrument, but re-expansion of bone after withdrawal of instrument means that width is not informative. Depth depends on force – generally instruments delivered forcefully will cause deep striations. Wastage and associated fractures are rare (force directed across rather than down). Hinge fractures (peeled away bone) can occur. Striations usually are present parallel to the cut
Chops (clefts or notches)	Usually caused by long or thick bladed instruments with at least one cutting edge. Cause complete interruption of the continuity of the bone. Usually sever a bone and cause chattering. Sharp and blunt injuries. Caused by vertical or near vertical forces applied by heavy instruments with long, sharp, edges. Usually results in a 'v' shaped wound that can penetrate the interior of the bone. Can be accompanied by extensive fracture lines, reflecting the power required to create them and the heaviness of the instruments causing them. May also be associated with hinging and, if there is enough force, wastage where sections of bone break away from the impacted bone. Can be short or long, depth depends on force applied. Generally associated with a downward force which results in striations vertical to the surface of the bone
Scoops	Small concave defect with multiple facets, where small 'flakes' of bone are removed. Results when the blade creates a fragment or wedge on removal. Generally associated with long-bladed weapons. Usually associated with complete fractures/deep penetration with blade held at similar angle as that causing the peeling or shaving described below
Peeling or shaving	A sleeve or bone fragment is lifted or peeled from the surface when the blade strikes bone at an angle or when the bone is twisted due to torsion. The fragment is not completely removed. Width and depth vary depending on penetration of the blade
Point insertions or notches	The point or tip of the instrument is directed perpendicular to the grain or surface of the bone – i.e. a stab wound. Indentation at point of impact, usually accompanied by small sections of bone breaking inward. Usually deep (extent depends on force and nature of instrument) and elongated with triangular or 'v' or cone shaped cross-section. Striations (usually only visible microscopically), associated fractures and hinge fractures can occur. Bone wastage rare
Slot fractures	Chopping wounds tend to fragment or penetrate the cranium resulting in multiple fractures as blade is removed. Appears as a wide groove with one straight edge and as associated curved or concentric fracture resulting from rotational movement of the blade as it is removed from the skull

Instrument attributes were further explored by consideration of the placement of injuries and features such as their size. For example, defects that crossed adjacent bones or bone regions suggested the use of a long instrument, and striations with internal micro-striations indicated the use of an instrument with a serrated edge (Byers 2005, 348; Kimmerle and Baraybar 2008). Radiating fractures and crushing are typical of heavy instruments, while thin-bladed instruments and thick edged instruments are generally associated with fine incisions and wide notches, respectively (Byers 2005, 348; Kimmerle and Baraybar 2008).

There are several studies in the forensic and archaeological literature that deal with the identification of specific weapons or tools using features observed on dry bone (for example, Smith and Brickley 2004; Humphrey and Hutchinson 2001; Tucker *et al.* 2001). Experiments using fresh bone and employing high powered microscopy (for example, SEM analysis) have generally been more successful at correctly attributing specific weapons to injuries than those that have relied on macroscopic analysis alone (Blumenschine *et al.* 1996; Tucker *et al.* 2001). Others have found that even microscopy cannot distinguish between specific instruments (Bartelink *et al.* 2001), highlighting the fact that fine distinctions are obscured by variations in the biomechanical responses of different bones (Kimmerle and Baraybar 2008, 267). For archaeological bone, distinctions are further blurred because of taphonomic processes, in particular erosive action from surrounding soil and other objects coming into contact with the bone in the burial environment and during excavation and post-excavation processes. Thus, no attempt was made to try and associate the features of injuries (macro- and micro- scopic) with specific weapons.

The direction of sharp force injuries was explored with reference to the features described by Boylston (2000, 361), Byers (2005, 348) and Knüsel (2005, 55). At a general level, injuries were concluded to have been delivered from behind if they were only seen on the posterior of the skeleton, and vice versa for those seen on the anterior. Where the same injury involved the anterior and posterior, direction was determined based on the principle that entry wounds are usually larger than exit wounds (Byers 2005, 348). More detailed observations were undertaken to explore the angle at which the instrument had travelled through the bone (Boylston 2000, 361). For example, horizontal cuts suggested blows delivered perpendicular to the long-axis of a bone (Kimmerle and Baraybar 2008, 270). In addition, a roughened margin, opposite to the polished/smooth margin, suggested the end point of a blow causing incomplete fracture, while a peeled bone surface was interpreted as the far margin of a blow in bone that has been bisected. Finally, lifting or a bony spall was interpreted as the end point in bone that has been nicked by a blow (Armit *et al*. 2011).

The position of the attacker was considered with reference to the location, angle and distribution of injuries. However, interpretations were made with caution because, unless angle was clear, injuries sustained to the back of the neck, for example, could have been made by an attacker standing behind, to the side or in front of the victim.

Multiple injuries were estimated by totalling the number of discrete primary injuries, based on points of impact and by reconstruction. This achieves an approximation at best, because it does not account for injuries sustained only to soft tissues and, where chops are concerned, is unable to account for defects that have been obliterated by subsequent blows. It is also not possible to distinguish between injuries received as the result of a fall onto a sharp object and an insult received as the result of a blow.

Reconstruction was an important part of interpreting multiple wounds. For example, in one individual a single blow could be identified from chop marks on the ulna and radius and cuts on the hand bones; the angle of these wounds and their distribution were consistent with a single blow from a sharp instrument that first chopped through the lower arm and terminated in the wrist.

Sequencing sharp force injuries could only be attempted on rare occasions where there was a relationship between fractures and there was sufficient bone preservation. This was undertaken using the principles set out by Rhine and Curran (1990) for projectile trauma.

Comparative analyses

Where appropriate, and depending on the availability of data, osteological findings were contextualised by comparison with assemblages from other European mass graves, several contemporary British attritional and execution cemeteries and the data presented by Roberts and Cox (2003, 166) which is based on a total of 7122 burials from 72 British cemetery sites dating between *c* AD 410 – *c* 1050. Table 3.4 provides a summary of the comparative assemblages. Although not all of the mass grave assemblages are directly contemporary with Ridgeway Hill, they are important parallels because, like Ridgeway Hill, they include individuals with multiple peri-mortem trauma who died in a single event (there are currently no known examples of this context from Britain that match the date span assigned to Ridgeway Hill, see Chapter 1). In

Table 3.4 Summary of comparative assemblages

Site	*Date*	*Type of assemblage / context*	*Number of individuals*	*Reference*
Mass graves				
St John's College, Oxford	Late Saxon (? AD 1002)	St Brice's day massacre? / raiding party	33 males (plus one unsexed juvenile)	Falys 2010
Heronbridge, Chester	AD 530–660	The Battle of Chester?	Approx. 34 (all males or probable males)	Davies 1933; Holst 2009
Towton, North Yorkshire	AD 1461	Victims of the Battle of Towton	Approx. 38 (males)	Fiorato *et al.* 2000
Uppsala, Sweden	16th century AD	Swedish warrior grave associated with the Battle of Good Friday	at least 60 (males)	Kjellström 2005
Visby, Sweden	AD 1361	Victims of the Battle of Wisby	Approx. 1,185 (males)	Ingelmark 1939
Other professional groups:				
Greenwich Royal Naval Hospital, London	18th–19th centuries AD	Retired pensioners from the Royal Navy	100 males, 7 females	Boston *et al.* 2008
The Mary Rose	AD 1545	Casualties from the Tudor warship	MNI 179 (males)	Stirland 2005
Contemporary cemeteries:				
St Andrew's Fishergate, York	11th century and 12th–14th centuries AD	Includes probable battle victims from the Church and priory	Priory: 271 (173 males); Church: 131 (47 males)	Stroud and Kemp 1993
Chesterton Lane Corner, Cambridge	Middle Anglo-Saxon	Execution cemetery	15 (14 males, 1 possible female)	Cessford *et al.* 2007
Walkington Wold, Yorkshire	Mid–late Saxon	Execution cemetery	13 crania and at least 12 infra-cranial skeletons (males and ?males)	Buckberry and Hadley 2007; Buckberry 2008
Old Dairy Cottage, Hampshire	Late 8th to 11th century AD	Execution cemetery	16 (sex not specified)	Cherryson 2005; 2008; Reynolds 2009
Castledyke South, Barton-on-Humber, Lincolnshire	Late 5th or early 6th century–7th century AD	Attritional cemetery	51 males or ?males	Boylston, Wiggins and Roberts 1998, 221
St Peter's, Barton-on-Humber Lincolnshire	Early phase: 10th–14th centuries AD Phases D-E	Attritional cemetery	304 males	Waldron 2007, 36

addition, most of them comprise soldiers killed in battle and therefore also provide useful comparative data on the health and physical attributes of those directly involved in battle. To this end, analysis has also made use of the data that has been gathered for two groups of mariners: the skeletons from the Tudor warship, *The Mary Rose* and skeletons from Greenwich Royal Naval Hospital (late 18th to 19th centuries).

RE-ASSOCIATION EXERCISE BETWEEN SKULLS AND SKELETONS

by Louise Loe, Helen Webb and Angela Boyle

A re-association exercise was undertaken in an attempt to match skulls with skeletons. This considered numbers of cervical vertebrae, bone size, bone morphology and patterns of trauma and pathology (in particular, joint disease). Cases were considered, first and foremost, based on the number of cervical vertebrae present with skulls, versus the number present with skeletons. For example, if a skull had cervical vertebrae (CV) 1–3, skeletons with CV 4–7 were considered.

Only six possible and one probable matches were made (Table 3.5), the exercise being considerably hampered by the fact that many cervical vertebrae could not be fully observed owing to fragmentation and bone loss as a result of peri-mortem trauma. However, the search for matches was not exhaustive, because it was beyond the scope of the present study to take each skull by turn and consider it against each skeleton in turn (an approach that may be beneficial given the aforementioned fragmentation and bone loss).

All of the seven matches that have been made should be regarded with caution. These mainly rely on the visual assessment of size, rather than more

Table 3.5 Summary of cranial and infra-cranial re-association exercise

Infra-cranial skeleton	*Skull*	*Comment*
3763	3694	Possible match: similar size and peri-mortem trauma patterns match
3800	3752	Possible match: similar age/size
3806	3736	Probable match: Left inferior body of CV6 matches/articulates well with left superior body of CV7. Also share similar extent of osteophytes
3754	3722	Possible match: similar age/size, but bones are incomplete, so cannot confirm a physical match
3754	3746	Possible match: similar age/size, but bones are incomplete, so cannot confirm a physical match
3778	3692	Possible match: similar age/size
3778	3729	Possible match: similar age/size

individualistic characteristics such as pathology, or detailed measurements. Further, re-association exercises can only really achieve a reliable result if they are supported by context information, or more specifically if a physical relationship between bones *in situ* can be demonstrated (for example, White 1992). All skulls were entirely divorced from their skeletons, so this important supporting contextual evidence does not exist.

THE SKULLS *by Angela Boyle*

Quantification

A total of 51 context numbers (hereafter referred to as skull numbers) were assigned to skulls in the field. However, one skull (3740) was not available for analysis, therefore the total number of skulls considered here is 50.

Five skulls (3686, 3693, 3694, 3725, 3737) had neither mandible nor vertebrae and this is largely due to damage by the mechanical excavator. Two (3732, 3739) comprised skulls and mandibles only. The remaining 43 were associated with at least one and as many as six cervical vertebrae.

Number of individuals

Minimum number counts are used in forensic and archaeological contexts in order to establish the smallest number of individuals (MNI) that could have contributed to a particular human bone assemblage (Boylston *et al.* 2000, 45). At Towton, the petrous temporal was counted to determine the minimum number of crania present. This method was also applied to the Ridgeway Hill skulls (including discrete skulls, all disarticulated skull fragments from 3681 and 3685 and skull 3740), providing an MNI of 45 based on the right temporal. A total of 40 left temporal bones were present, and in addition a further 3 right and 2 left discrete temporal bones were counted within the disarticulated material (see below and Appendix 2). If these bones are included, then the MNI is 48 based on the right temporal. The MLNI (minimum likely number of individuals) has recently been presented as a more statistically accurate modification of the MNI (Adams and Konigsberg 2008, 241) and employs the most frequently occurring number of paired elements (in this case, the temporal bone), applied to the following equation:

$$\mathrm{MLNI} = \frac{(L+1)(R+1)}{(P+1)} - 1.$$

L=left, R= right, P=paired

The resulting total for the Ridgeway Hill skulls is 47 (excluding disarticulated temporal bones, none of which could be paired).

Preservation, completeness and element representation

A total of 41 out of the 50 contexts had suffered some level of machine damage. Completeness was determined by scoring the presence/absence of 32 separate skull components (frontal, left parietal, right parietal, etc.) (see Fig. 3.1). A total of 29 skulls were more than half complete.

In most cases the more fragile bones of the facial region were damaged or destroyed. This is reflected by the low numbers of nasal (4 left, 4 right), ethmoid (1 left, 1 right) and lacrimal (1 left, 1 right) bones which survived (see Fig. 3.2). In most cases very small fragments of unidentified bone were present

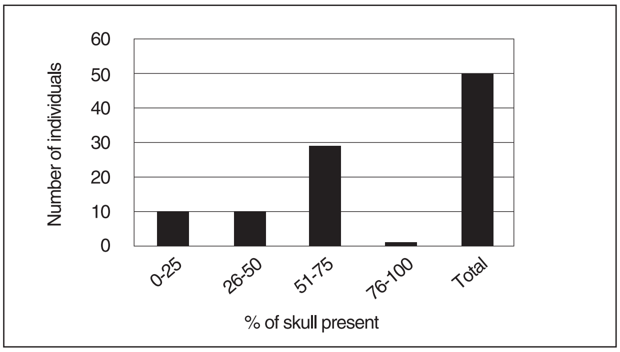


Fig. 3.1 Completeness of skulls

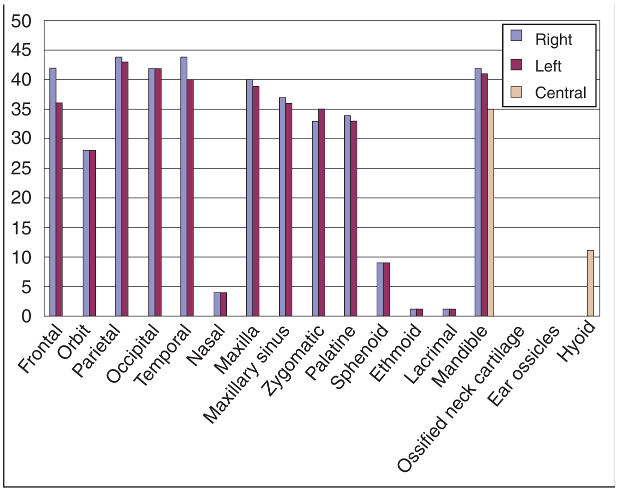


Fig. 3.2 Number of cranial elements present

and these are likely to represent these fragile bones. The poor preservation of these bones has implications for the recording of sinusitis. While a reasonably high number of frontal bones survived, in many cases these were damaged and orbital bones were particularly affected.

A total of 140 out of a possible 350 (40%) vertebrae survived (assuming one skull = seven vertebrae).

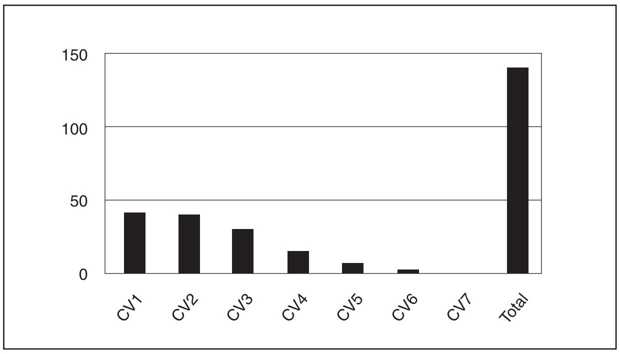


Fig. 3.3 Number of cervical vertebrae present

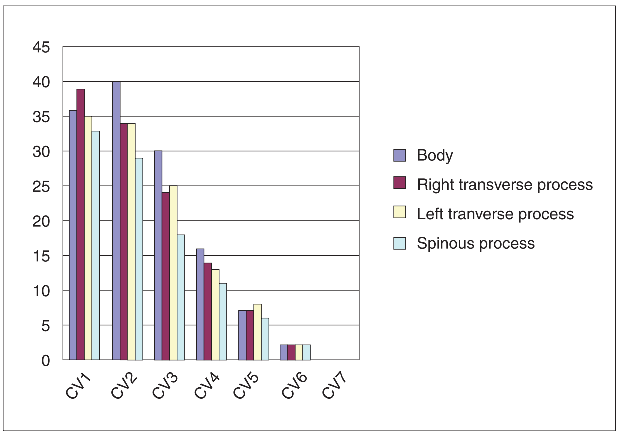


Fig. 3.4 Number of vertebral elements present with skulls

The distribution of surviving vertebrae are summarised in Fig. 3.3. The first and second vertebrae most commonly survived (42/50 CPR 84%, 41/50 CPR 82%).

A total of 43 skulls had one or more cervical vertebrae attached. These have been scored using the zonation system of Knüsel and Outram (2004, 88, fig. 2a) which divides each vertebra into four zones (body, right transverse process, left transverse process and spinous process). A total of 467 elements out of a possible 1400 were present. The latter figure assumes the possible presence of all four elements of all seven cervical vertebrae. No less than 113 elements displayed evidence of sharp force trauma (113/467, TPR 24.2%). A total of 62 out of 140 surviving vertebrae were affected. The distribution of surviving elements is summarised in Fig. 3.4.

Considering bone surface condition, the vast majority of skulls were classified as having slight and patchy surface erosion (category 1, see Table 3.1 and Fig. 3.5). No modifications were observed on bone surfaces that are consistent with tooth, claw, or other marks resulting from animal scavenging (for

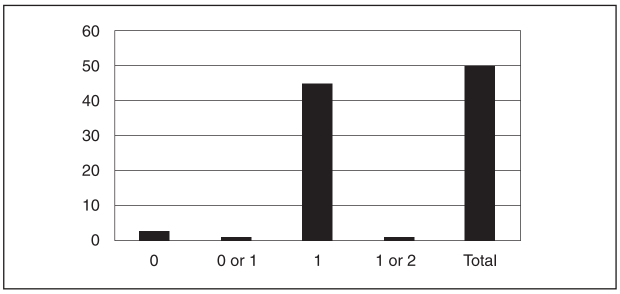


Fig. 3.5 Bone surface condition of skulls (after McKinley 2004, 16)

Table 3.6 Intrusive elements

Skull	*Element identification*
3692	3 left zygomatic bones
3696	2 left temporal
3708	1 left frontal
3710	1 right mandible with sharp force trauma
3724	1 left frontal
	1 anterior mandible with sharp force trauma
3730	1 left maxilla
	1 left mandible with sharp force trauma
3735	1 unsided occipital fragment with sharp force trauma
3738	I left facet (CV1)
3743	1 right frontal
	1 left frontal
	1 left parietal
	1 right occipital
	2 right zygomatic bones
	1 incisor, 2 premolars, 3 molars
3760	1 hyoid

example, see Binford 1981; Blumenschine *et al*. 1996; Bunn 1981; Haglund *et al*. 1988; Lyman 1994).

A total of 10 skulls (3692, 3696, 3708, 3710, 3724, 3730, 3735, 3738, 3743, 3760) contained intrusive elements from other skulls (see Table 3.6). Skull 3692 was the most southerly of a north-south alignment of five skulls (3692, 3693, 3694, 3695, 3696) which lay above the main concentration of skulls. All of these were highly fragmented. There were three intrusive left zygomatic bones which are likely to have belonged to one of the other skulls in this group for which no zygomatic bones were present. No more than four examples of any skeletal element were present within this group of five skulls so it is possible that only four skulls are actually represented.

Skull 3708 was located on the northern edge of the deposit immediately east of skull 3712, to the south-west of skull 3704 and immediately north of skull 3706. An intrusive left frontal did not belong to skulls 3704, 3706 or 3712. An intrusive fragment of mandible associated with skull 3710 did not appear to be related to any of the immediately adjacent skulls. It was a right gonial fragment of a mandible with marked flaring which had been removed by sharp force trauma. Skull 3724 had an intrusive fragment of anterior mandible with sharp force trauma; a second left frontal was also present and may belong to skull 3728. A fragment of left mandible found with skull 3730 had a large diagonal chop which had removed a portion of the ascending ramus. There was also an intrusive left maxilla. The dentition suggested a young adult and it is possible, though not certain, that these belonged to skull 3731. Skull 3735 was associated with an intrusive fragment of occipital with sharp force trauma which had exposed the diplöe and caused a polished appearance. A single left facet belonging to a first cervical vertebra was found with skull 3738. Skull 3743 was badly damaged by the mechanical excavator. Intrusive bones comprised a left and right frontal and two right zygomatic bones which could belong to skull 3741 as they were from a young adult; the association of a left parietal and a right occipital is less clear. There were also intrusive teeth (two premolars, one incisor and three molars). A number of cranial and vertebral elements were present in the disarticulated material and these are considered below and detailed in Appendix 2.

Fig. 3.6 Skull 3761

Table 3.7 Summary of age indicators employed for each individual skull

Skull	*Final estimated age range*	*Age category assigned for analysis*	*Dental eruption*	*Spheno-occipital synchondrosis*	*Dental attrition (Miles 1962)*
3686	18+ y	Adult	No dentition	Absent	No dentition
3692	30-35 y	Prime adult	8s fully formed and erupted	Absent	30-36 y (1st molars)
3693	18+ y	Adult	No dentition	Absent	No dentition
3694	18-25 y	Young adult	8s fully formed and erupted	Absent	18 y
3695	18-24 y	Young adult	8s fully formed and erupted	Absent	18-24 y
3696	18-25 y	Young adult	8s erupting, roots incomplete	Absent	18-24 y
3704	18-25 y	Young adult	8s fully formed and erupted	Absent	18-24 y
3705	36-44 y	Mature adult	8s fully formed and erupted	Fused	36-44 y
3706	18-24 y	Young adult	8s fully formed and erupted	Fused	18-24 y

Ancestry

Only one skull – 3761 – had survived reasonably intact and could be assessed to determine ancestry (Fig. 3.6). The skull possessed cranio-facial morphological traits that were predominantly consistent with those described by Gill (1986) for individuals of white ancestry. In particular this included a sharp nasal sill, reduced facial and alveolar prognathism and a prominent chin projection. The saggital outline was also high and rounded and the cranial form was medium, as opposed to broad (east Asian), medium-broad (American Indian), highly variable (Polynesian) or long (Black) (Gill 1986).

Measurements taken from the skull were found to be well catered for in the CRANID6 database (Wright 2012), which showed that it most closely resembled male crania from Neolithic Denmark, with a high probability score of 0.98543. London medieval male crania are the next group that the skull most closely resembled, but with a much lower probability score of 0.0726.

Biological sex

It was possible to estimate the sex for 47 of the skulls. The majority – 43 in total – had features that were strongly male and were therefore classified as definite males. A further four skulls were assigned to the probable male category. These were all young adults that did not have the full suite of skull traits available for assessment and/or had some features that were not as strongly male compared with the rest of the assemblage. This latter point is in keeping with the observed tendency for male skulls to have a feminine appearance until puberty has ceased, which can last into their twenties (Cox 2000; Walker 1995). Finally, in three skulls (3696, 3725, 3737) extreme fragmentation precluded sex estimation.

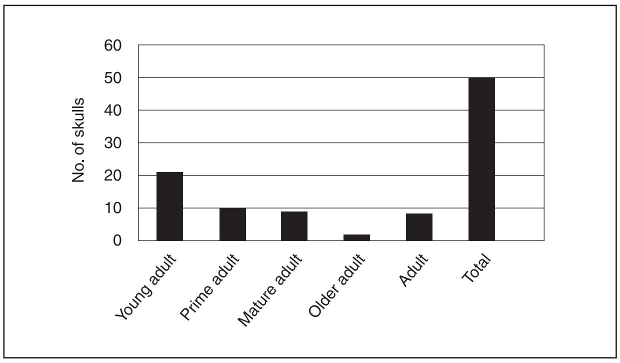


Fig. 3.7 Mortality profile of skulls

Biological age

All of the skulls were aged without reference to data on the skeletons and were found to range from young adult to older adult (see Fig. 3.7). There were 21 young adults (18–25 years), 10 prime adults (26–35 years), nine mature adults (36–45 years), two older adults (45+ years) and eight aged upwards of 18 years. Seven of the skulls (3720, 3722, 3724, 3730, 3739, 3742 and 3757) assigned to the young adult age category were from individuals aged between 17 and 18 years old, so could conceivably be adolescents. This was the youngest age range assigned to the skulls. The two oldest skulls were estimated to have been from individuals aged 45–50 years (3751) and 45–52 years (3721) old. Table 3.7 presents details of the ageing methods employed for each individual skull.

Dental attrition as an ageing method

Dental attrition is a physiological process resulting from tooth-on-tooth contact which increases in severity over time, hence its use in the estimation of age. It is not to be confused with dental abrasion, which is the wearing away of enamel by a mechanical process or by an abrasive material. The method

Dental attrition (Brothwell 1981)	*Cranial suture closure (Meindl and Lovejoy 1985)*	*Arachnoid granulations (Barber 1997)*
No dentition	Moderate, not formally scored	Left and right parietal, none present
25-35 y	Skull fragmented	At least 25 y, insufficient surviving of left and right parietal
No dentition	Skull fragmented	Insufficient surviving of left and right parietal
17-25 y	Skull fragmented	Insufficient surviving, left parietal only
17-25 y	Skull fragmented	Left and right parietal, possibly 40+y
17-25 y	Skull fragmented	25y right parietal only
17-25 y	Open	Left and right parietal, 25+ y
33-45 y	Advanced	Left and right parietal, none
17-25 y	Very fragmented, not formally scored, minimal	Left and right parietal, none

Table 3.7 (continued)

Skull	*Final estimated age range*	*Age category assigned for analysis*	*Dental eruption*	*Spheno-occipital synchondrosis*	*Dental attrition (Miles 1962)*
3707	25-35 y	Prime adult	8s fully formed and erupted	Fused	Irregular wear, 8 would suggest age approx. 52y, 6 = 36 y
3708	35-42 y	Mature adult	8s fully formed and erupted	Absent	42-60 y, very irregular wear
3709	35-45 y	Mature adult	8s fully formed and erupted	Fused	38-42 y
3710	26-35 y	Prime adult	8s fully formed and erupted	Absent	25-36 y
3711	35-40y	Mature adult	8s fully formed and erupted	Fused	36 y
3712	35-40 y	Mature adult	8s fully formed and erupted	Absent	36 y
3720	17-18 y	Young adult	8s erupting, roots incomplete	Unfused	18 y
3721	45-52 y	Older adult	8s fully formed and erupted	Fused	42-52 y
3722	17-18 y	Young adult	8s erupting, roots incomplete	Unfused	12-18 y
3723	18+ y	Adult	8 fully formed and erupted	Damaged, probable fusion	30-60 y
3724	17-18 y	Young adult	8s erupted, root tips open	Fused	No wear, 16-18 y
3725	18-24 y	Young adult	8 roots complete	Absent	18-24 y
3726	18-24 y	Young adult	8s fully formed and erupted	Absent	18-24 y
3728	18+ y	Adult	A single 8 erupted	Absent	No wear, 16-18 y
3729	35-45 y	Mature adult	8 fully formed and erupted	Absent	42-52 y
3730	17-18 y	Young adult	8s erupting, roots incomplete	Unfused	12-18 y
3731	18+ y	Adult	No dentition	Absent	No dentition
3732	18+ y	Adult	8s full formed and erupted	Absent	No dentition
3733	18-25 y	Young adult	8s fully formed and erupted	Absent	*c* 18 y
3734	18-25 y	Young adult	8 erupting, roots 50% complete	Absent	*c* 18 y
3735	42-45 y	Mature adult	8s formed and fully erupted	Fused	42-60 y
3736	25-35 y	Prime adult	8s fully formed and erupted	Absent	25-35 y
3737	18+ y	Adult	Absent	Absent	Absent
3738	24-27 y	Prime adult	8s fully formed and erupted	Fused? Difficult to tell due to damage	24 y based on 6s
3739	17-18 y	Young adult	8 roots two thirds complete, partial eruption of right lower 8	Absent	16-18 y
3741	18+ y	Adult	Absent	Absent	Absent
3742	17-18 y	Young adult	8s fully formed and erupted	Unfused	12-18 y
3743	27-35 y	Prime adult	8s fully formed and erupted	Fused	24-36 y
3744	25-30 y	Prime adult	8s fully formed and erupted	Fused	20-30 y
3746	18-25 y	Young adult	In crypt, alveolar bone perforated	Absent	*c* 18 y
3747	20-22 y	Young adult	8s erupted, root tips open	?Fused difficult to be certain due to damage	Less than 18 y
3748	44-45 y	Mature adult	8s fully formed and erupted	Fused	42-50 y
3749	18-25 y	Young adult	8s fully formed and erupted	Absent	*c* 18 y
3750	42-45 y	Mature adult	8s fully formed and erupted	Fused	42-46 y
3751	45-50 y	Older adult	8s fully formed and erupted	Fused	42-46 y
3752	26-35 y	Prime adult	8s fully formed and erupted	Absent	30-42 y
3757	17-18 y	Young adult	8s full formed and erupted	Unfused	*c* 18 y
3758	30-35 y	Prime adult	8s fully formed and erupted	Absent	30-32 y
3759	18-20 y	Young adult	Partially erupted 8, roots complete	Fused	18-20 y
3760	18-25 y	Young adult	8s erupting, roots incomplete	Too damaged	*c* 18 y
3761	18-27 y	Prime adult	8s fully formed and erupted	Fused	18-30 y

Dental attrition (Brothwell 1981)	*Cranial suture closure (Meindl and Lovejoy 1985)*	*Arachnoid granulations (Barber 1997)*
25-35 y	Very fragmented, not formally scored	Left and right parietal, 25
33-45 y	Significant, not formally scored due to fragmentation	Left and right parietal, 35 y
25-35 y	Significant, not formally scored	Left and right parietal, 45 y
25-35 y	Not formally scored, moderate closure	Left and right parietal, 25 y
25-35 y	Open	Left and right parietal, 40+ y
25-35 y	Open	Left and right parietal, 40+ y
17-25 y	Open	Left and right parietal, none present
45+ y	27-45 y	Left and right parietal, 40 y
17-25 y	Open	Left and right parietal, none present
odd wear pattern, only 3 molars	Open	None, only right parietal present
17-25 y	Fragmented	Left and right parietal, 30 y
17-25 y	Incomplete	No parietals
17-25 y	Fragmented	Left and right parietal, none
a single 3rd molar	Incomplete	No parietals
25-35 y upper/ 33-45 y lower	27-44 y	Left and right parietals, 45 y
17-25 y	Open	Left and right parietals, 25 y
No dentition	Minimal	Left and right parietals, 30+ y
No dentition	Open	Left parietal only, 3 y
17-25 y	20-45 y	Left and right parietals, 25 y
17-25 y	Open	No parietals
36-45 y	30-60 y	Left and right parietals, 35 y
25-35 y	Moderate, not formally scored due to fragmentation	Left and right parietals, 25 y
Absent	Significant, very fragmented and incomplete	Right parietal only, none present
17-25 y	27-44 y	Left and right parietals, none present
17-25 y	Open	Left and right parietals, none present
Absent	Incomplete	Left and right parietals, none present
less than 17 y	Open	Left and right parietals, none present
25-35 y/45+ y	27-44 y	Left and right parietals, at least 35 y
25-35 y	Open	Left and right parietals, none present
17-25 y	Open	Left and right parietals, 25 y
17-25 y	22-45 y	Left and right parietals, 20 y
45+ y	27-44 y	Left and right parietals, 50 y
17-25 y	Open	Left and right parietals, 25 y
33-45 y	30-60 y	Left and right parietals, 35+ y
45+ y	30-60 y	Left and right parietals, 50 y
25-35 y	No significant closure	Left and right parietals, 25 y
17-25 y	Minimal	Left and right parietals, none present
25-35 y	27-44 y	Left and right parietals, 30 y
17-25 y	20-34 y	Left and right parietals, none present
17-25 y	Open	Left and right parietals, 30 y
17-25 y	27-54 y	Skull complete, not scored

employs observations of attrition patterns on the adult molar teeth (for which attrition is most predictable compared with other teeth in the dental arcade) with reference to the schemas devised by Brothwell (1981) and Miles (1962) for archaeological populations. Generally speaking, the molars exhibit increased wear patterns relative to the time that they have been in contact with occluding teeth following their eruption into the jaw; thus first molars will show greater attrition compared with second molars, which will have greater attrition than third molars, this pattern being relative to the order in which these teeth erupt. The method is most successful when attrition rates are established for the particular population being studied, but this requires sufficient numbers of juveniles with different stages of molar tooth eruption (Miles 1962).

In the present sample, the application of dental attrition to estimate age was very problematic because considerable variation was observed between molars belonging to the same dentition. In addition, the method suggested ages that conflicted with other age estimation methods. For example, in the case of skull 3707 wear on the left mandibular first and third molars was considerable to the extent that it was almost cup-like (Fig. 3.8). The depressions measured approximately 5mm in depth and there was dentine exposure. The distal edge of the third molar was concave and overall the appearance was consistent with an age of *c* 52 years (the first molar was consistent with *c* 36 years). In contrast, all second molars were considerably less worn with only minimal dentine exposure, consistent with a younger age. This unusual pattern of wear could be related to some form of non-masticatory activity and has not been considered when using attrition as an ageing method for this individual.

In the case of skull 3723, wear on the left maxillary second and third molars was far greater than that on the left maxillary first molar (Fig. 3.9). The only two other surviving molars were the right maxillary first and second which comprised roots only (see section on dental trauma below).

Skull 3729 had advanced bilateral wear on the mandibular first and second molars with far less on the corresponding maxillary molars (Fig. 3.10). The former places the individual in the 33–45 year category while the wear on the maxillary molars suggests 25–33 years (Brothwell 1981, 72).

Skull 3743 had advanced wear on the maxillary right first molar with near complete dentine exposure, sloping down, diagonally from buccal to lingual; the adjacent second premolar also has marked dentine exposure. Less wear is apparent on the other first molars (Fig. 3.11).

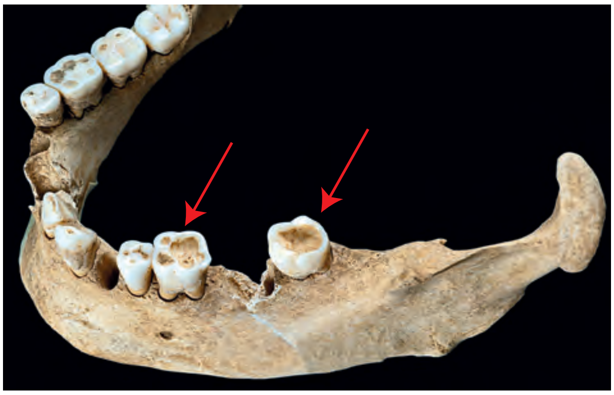


Fig. 3.8 Skull 3707, unusual mandibular wear (arrowed)

Fig. 3.9 Skull 3723, unusual maxilliary wear (arrowed)

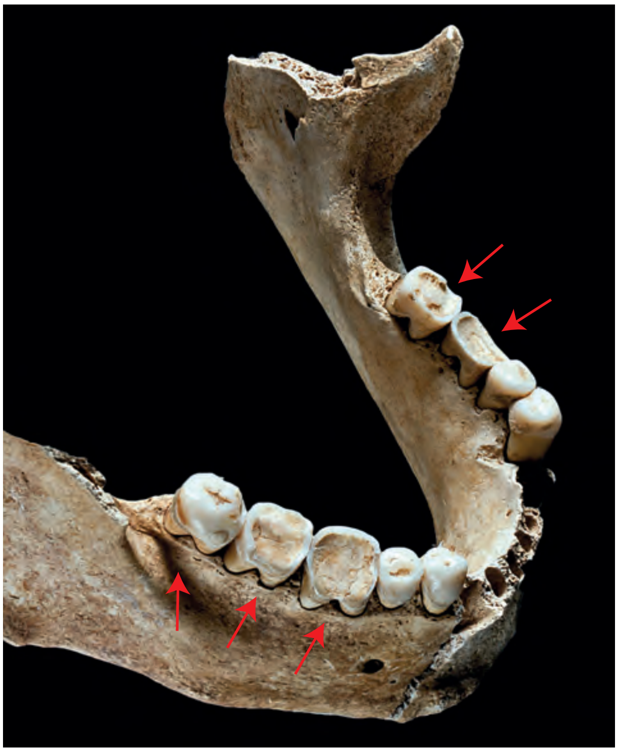


Fig. 3.10 Skull 3729, unusual mandibular wear (arrowed)

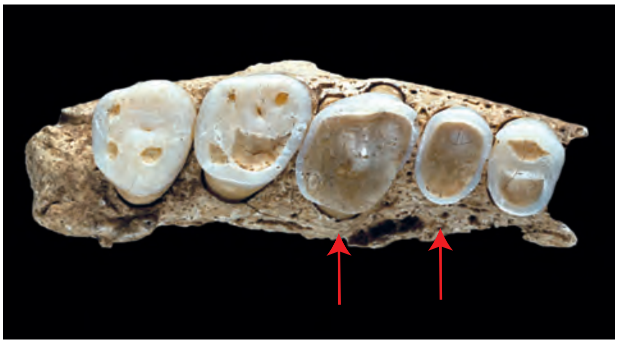


Fig. 3.11 Skull 3743, unusual maxilliary wear (arrowed)

At St John's College, Oxford seven individuals with pronounced tooth wear displayed conflicting age ranges which made them 10–20 years older compared with other osteological ageing methods (Falys 2010, 51). These included skeletons 1852 and 1978 who had extreme wear involving all first molars. In addition, skeletons 1787 and 1963 were observed to have pronounced wear on their anterior dentitions, exposing significant areas of dentine.

Abnormal dental attrition observed among the Ridgeway Hill skeletons is discussed further in a later section of this chapter, under 'Dental health'.

Arachnoid granulations as an ageing method

Consideration was given to the use of arachnoid granulations for age estimation (Barber 1997; Barber *et al.* nd). This method employs a count of the number of arachnoid granulations on the endocranial surface of the skull which, generally speaking, increase in number and size with the advancement of age (Du Boulay 1980). It is considered to be most useful when applied to males and females aged upwards of 40 years (Barber 1997). Arachnoid granulations are identified on dry bone as pits or depressions of variable shape, situated up to 30mm on either side of the sagittal sinus on the left and right parietals. They also appear in the frontal bone but are much smaller and more numerous in number (Le Gros Clarke 1920). The method counts isolated pits/depressions or clustered pits/depressions as one. Put simply, if there are over seven pits present then the individual is more than 50 years old (Barber *et al*. nd, 14). If only one parietal is present the method can be applied with caution as there are normally no differences in the total number of pits and depressions on left and right sides (Barber 1997).

This method was applied to 41 of the skulls from Ridgeway Hill (41/50, 82%). In most cases there was good agreement with the other ageing methods employed (see Table 3.7). A notable exception was skull 3695 where dental attrition placed it in the young adult age category, while the count of arachnoid granulations suggested 40+ years. In addition, they suggested 30+ years for young adult 3724.

Cranial suture closure as an ageing method

A total of 13 skulls could be formally scored for cranial suture closure after Meindl and Lovejoy (1985). For the remaining skulls, which were too fragmentary and/or incomplete to be formally scored, a subjective assessment was provided that employed the classifications: 'open', 'minimal', and 'significant'.

Epiphyseal fusion as an ageing method

The spheno-occipital synchondrosis was only present in 24 cases, five of which were unfused. Six individuals had immature cervical vertebrae (3706, 3722, 3730, 3734, 3742, 3757) while non-fusion of hyoid horns was seen in four cases (3705, 3724, 3751, 3757). The hyoid bone usually fuses in the late 20s or 30s (Boylston *et al.* 2000, 51).

Metrical assessment

Measurements could be taken from a total of 24 skulls and were almost exclusively from the mandible and the atlas (Table 3.8). They were limited in number because the majority of skulls were highly fragmented (see section on preservation above) and reconstruction was beyond the scope of the work. The small size of the dataset precludes meaningful comparison with other assemblages.

One skull (3761) was sufficiently intact for a range of measurements to be taken and employed in the calculation of the cranial, nasal and orbital indices. Indices are a means of exploring variability within and between populations in terms of shape, expressed numerically as a percentage, by the ratio of one measurement to another (Brothwell 1981, 87). Indices have been classified into categories, with the lowest referring to a narrow shape and the highest referring to a broad shape, or vice versa depending on the index (Table 3.9; Brothwell 1981; Bass 1987).

The present individual's cranial, nasal and orbital indices all fell at the bottom end of the average or medium ranges, suggesting a relatively narrow skull and nasal bone and wide orbits. The cranial index contrasts with contemporary skeletons from Saint Andrew's Fishergate, where they ranged from 76.24–87.53 reflecting a tendency towards a broader shape (Stroud and Kemp 1993, 180), but is similar to male skulls from several contemporary sites in Denmark (mean: 74.6; range: 70.4–79.7; Sellevold *et al.* 1984, 178-9), where a tendency towards a narrow shape is also reflected.

Table 3.8 Summary of skull measurements

Measurement	*Number*	*Range (mm)*	*Mean (mm)*
Atlas – maximum internal width	11	24.8–27.3	25.8
Maximum mandibular length ML	1	100	
Mandibular bigonial breadth GOGO	3	92–111	99.9
Mandible – foramen mentale breadth ZZ	6	36.6–48.4	43.5
Mandible – bicondylar breadth WI	2	114.5–121.3	117.9
Mandible – left minimum ramus breadth RB	13	25.6–40.3	32.5
Mandible – right minimum ramus breadth RB	15	25.6–38.5	31.5
Maximum cranial length GOL	1	190	
Nasio-occipital length NOL	1	185	
Cranial base length BNL	1	104	
Basion-bregma height BBH	1	138	
Max cranial breadth XCB	1	145	
Max frontal breadth XFB	1	120	
Biauricular breadth AUB	1	124	
Biasterionic breadth ASB	1	117	
Basion to prosthion length BPL	1	101	
Upper facial height NPH	1	68	
Nasal height NLH	1	50	
Orbital height OBH	1	31 (L and R)	
Orbital breadth OBB	1	37 (L and R)	
Bijugal breadth JUB	1	110	
Nasal breadth NLB	1	24	
Maxillo-alveolare breadth MAB	1	65	
Bimaxillary breadth ZMB	1	92	
Zygo-maxillary subtense SSS	1	27	
Bifrontal breadth/upper facial breadth FMB	1	98	
Nasion-frontal subtense NAS	1	16	
Biorbital breadth EKB	1	96	
Interorbital breadth DKB	1	22	
Cheek height WMH	1	24	
Frontal chord FRC	1	117	
Nasion-bregma subtense FRS	1	29	
Parietal chord PAC	1	109	
Bregma-lambda subtense PAS	1	21	
Occipital chord OCC	1	103	
Lambda-opisthion subtense OCS	1	31	

L= left; R = Right

Table 3.9 Summary of indices calculated for skull 3761

Index	*Definition*	*Ranges (after Bass 1987)*	*Skull 3761*
Cranial index	Ratio of breadth to length	Dolichocranic (narrow or long): <75.00	
		Mesocranic (average or medium): 75.00 – 79.99	
		Bracycranic (broad or round): 80.00 – 84.99	
		Hyperbrachycranic (very broad headed): 85.0 / >85.0	76.32
Nasal index	Relation of breadth to height of the anterior nasal aperture	Leptorrhinic (narrow nasal aperture): X – 47.99	
		Mesorrhinic (average or medium): 48.00 – 52.99	
		Platyrrhinic (broad or wide nasal aperture): 53.00 - X	48.00
Orbital index	Relation of height to breadth	Chamaeconchic (wide orbits): X – 82.99	
		Mesoconchic (average or medium): 83.00 – 89.99	
		Hypsiconchic (narrow orbits): 89.00- X	83.78

The nasal and orbital indices are also consistent with the Danish populations (ibid.).

Non-metrical assessment

Cranial and vertebral traits

Human characteristics occur for a variety of reasons, including (but not limited to): environment, geography, diet, genetic inheritance and phenotypic expression of that inheritance. Certain characteristics have been shown to have a heritable aetiology.

Non-metric traits are morphological skeletal variations that are not normally indicative of pathology condition or disease, but are also not considered standard features of bone. Many of these traits have been found to have a heritable factor, suggesting some level of population affinity. Some of these traits have also been linked to biomechanics and occupational patterns allowing for other possible human comparisons and connections (Corruccini 1974; Finnegan 1978; Brasili *et al.* 1990). Variations in skeletal morphology may indicate population diversity or homogeneity. The potential interpretative possibilities for individual traits is complex and most are not yet readily definable, particularly at a 'local' archaeological level (Tyrrell 2000, 289). Table 3.10 details the cranial and vertebral non-metric traits observed.

Dental anomalies

The genetics of most skeletal traits are not well established, however, a number of dental anomalies have been shown to 'run in families' (Berry 1978; Brook 1984). These include enlarged and supernumerary teeth, reduced and missing teeth (hypodontia or agenesis). A range of anomalies was

Table 3.10 True prevalence of cranial and vertebral non-metrical traits

Trait	*Right n/N*	*%*	*Left n/N*	*%*	*Unsided n/N*	*%*
Ossicle at lambda					3/33	9.09
Lambdoid ossicles	23/34	67.65	23/35	65.71		
Sagittal ossicles					28/39	71.79
Coronal ossicles	14/31	45.16	13/31	41.94		
Ossicle at asterion	1/14	7.14	3/14	21.43		
Parietal notch bone	0/18	0	1/17	5.88		
Metopism					3/40	7.5
Palatine torus	1/36	2.78	1/35	2.86		
Mandibular torus	1/37	2.7	0/35	0		
Highest nuchal line					1/37	2.7
Parietal foramen	13/43	30.23	11/41	26.83		
Accessory infra-orbital foramen	1/12	8.33	0/10	0		
Absent zygomatico facial foramen	0/27	0	2/28	7.14		
Supra-orbital foramen (bridged notch)	7/34	20.59	4/27	14.81		
Accessory supra-orbital foramen	6/28	21.43	3/23	13.04		
Mastoid foramen extra-sutural	4/32	12.5	2/25	8.00		
Double condylar facet	3/24	12.5	2/22	9.09		
Atlas facet form double	11/33	33.33	6/30	20.00		
Atlas lateral bridge	0/24	0	0/23	0		
Atlas posterior bridge	0/24	0	0/23	0		
Atlas bipartite transverse foramen	0/24	0	0/23	0		

Table 3.11 Number and type of dental anomalies observed (N=number of skulls with dentition)

CPR	*TPR*	*Skull No.*	*Dental anomaly*
4/44 (9.09%)	12/1079 (1.10%)	3711, 3746, 3760, 3761	Crowding
1/44 (2.27%)	1/1079 (0.09%)	3759	Impaction
1/44 (2.27%)	1/1079 (0.09%)	3761	Peg molar
6/44 (13.64%)	11/1079 (1.02%)	3692, 3707, 3726, 3735, 3738, 3747	Rotation
3/44 (6.82%)	5/1079 (0.46%)	3720, 3722, 3738	Microdontia
1/44 (2.27%)	1/1079 (0.09%)	3734	Carabelli's cusp
7/44 (15.90%)	15/123 (12.20%)	3704, 3712, 3729, 3744, 3748, 3759, 3760	Agenesis of the third molar

observed among the skulls and these are summarised in Table 3.11.

Six individuals had rotated teeth: skull 3692 had rotation of the lower right canine; skull 3707 had slight rotation of the upper right second incisor; the upper left canine of skull 3726 was rotated so that its lingual surface occluded with the mesial surface of the upper left first premolar; skull 3735 had rotation of the lower left second incisor and canine and the upper left canine; skull 3747 had slight rotation of all mandibular incisors. The upper second incisors of skull 3738 had microdontia and were both rotated.

Four individuals had crowding: skull 3711 had crowding of all mandibular incisors; skull 3746 had crowding of the upper left incisors and canine, with displacement of the upper left second incisor; the lower left canine of skull 3760 was slightly displaced in an anterior direction; there was also an accessory tooth in the maxilla between the canine and the first premolar on both sides, both were very worn in a downwards sloping labial to lingual direction; skull 3761 had slight crowding of the mandibular incisors. Irregularity and overlapping of the anterior teeth was so common as to be almost normal. Some were merely twisted out of position, but others were wholly displaced to lingual or labial (Hillson 1996, 112).

A total of seven individuals did not have their third molars (skulls 3704, 3712, 3729, 3744, 3748, 3759, 3760), however radiography is required to determine whether this refers to agenesis, impaction, or loss through injury or disease. The third molars were the most frequently missing teeth followed by upper second incisors, upper or lower second premolars, lower first incisors, and upper or lower first premolars (Hillson 1996, 113). Properly, impaction implies that the tooth remains inside the jaw and does not emerge into the mouth at all, but there are many variations and a tooth may erupt sideways into its neighbour, presenting one of its crown sides uppermost. The most commonly impacted tooth is the third molar, especially the lower, followed by the upper canine (Hillson 1996, 113). Skull 3759 had a slightly impacted mandibular left third molar.

A few miscellaneous traits were also observed. The upper second incisors of skulls 3722 and 3738 were microdontic (abnormally small), the latter were also rotated. Skull 3720 had retention of the mandibular left deciduous second molar, while the maxillary left third molar had microdontia. Skull 3761 had an accessory microdontic tooth in the crypt, which was located posterior to the maxillary right third molar. A Carabelli's cusp was present on the maxillary right third molar of skull 3734. This is classified as a non-metrical variation (Hillson 1996, 85).

Dental Health

Examining dental health and rates of dental disease can provide some evidence of an individual's diet. Poor dental health is in part related to poor oral hygiene, but is also likely to be associated with the consumption of carbohydrates, particularly sucrose. Dental diseases are often inter-related: for example advanced attrition can increase the likelihood of developing a carious lesion which can in turn lead to periapical inflammation and in turn to ante-mortem tooth loss.

The evidence suggests that dental health was generally good amongst the Ridgeway Hill individuals. A total of 44 out of the 50 skulls had a surviving dentition (one or more teeth and/or jaws). The total number of teeth present was 1079 and most were reasonably well preserved. The rates for ante-mortem tooth loss, enamel hypoplasia, caries, periapical cavities and calculus have been compared with data from Roberts and

Table 3.12 Summary of dental pathology (TPR, number of individuals=44, number of teeth=1079, number of sockets 1089) at Ridgeway Hill compared with a range of other sites

	Ridgeway Hill	*St John's*	*Roberts and Cox (2003, 190-4)*	*Towton*
Ante-mortem tooth loss	13/1089 1.2%	5/628 0.8%	3330/41400 8.0%	71/698 10.2%
Enamel hypoplasia	14/1079 1.3%	*	*	35/698 5.0%
Caries	6/1079 0.6%	8/628 1.3%	1636/38911 4.2%	62/698 8.9%
Calculus	463/1079 42.9%	*	1399/3567 39.2%	549/698 78.6%
Abscess	4/1089 0.4%	4/628 0.6%	1145/41705 2.7%	5/698 0.7%

*Data not readily available

Cox (2003, 190-4), St John's College (Falys 2010) and Towton (Holst and Coughlan 2000) (see Table 3.12).

Caries

Caries are cavities that result from the demineralisation of teeth when they are attacked by acids that develop when bacteria ferment food sugars, especially sucrose. A total of four individuals had carious cavities (4/44, CPR 9.1%; 6/1079 TPR 0.56%), including two mature adults (skulls 3712 and 3750), one young adult (skull 3730) and one prime adult (skull 3761). Each individual had one cavity with the exception of skull 3750 which had three. Affected teeth included four second molars and two third molars, giving a total TPR of 0.56% (6/1079). This rate is less than half that recorded at St John's College (1.3%) and very much lower than the combined TPR given in Roberts and Cox (2003, 190-1) (4.2%) for 36 broadly contemporary assemblages. The rate at Towton is 8.9%, although the assemblage is considerably later in date.

Calculus

Calculus is a build-up of mineralised dental plaque, which can result from poor dental hygiene and a high protein diet. The prevalence of calculus among the Ridgeway Hill skulls is broadly comparable with the figures produced by Roberts and Cox (2003, 190-4). A total of 39 skulls (CPR 88.6%, 39/44) had 463 teeth (TPR 42.91%; 463/1079) with calculus. Comparative data was not available for St John's College at the time of writing.

Periapical cavities

These are identified as openings or holes in the periapical bone of the mandible or maxilla at the apex of the tooth root. They arise as a result of inflammation of the dental pulp which can occur as a result of trauma, caries or attrition. Depending on severity, these cavities may contain granulation tissue (a 'granuloma'), a fluid filled sac (a 'periapical cyst') or a pus-filled sac (an 'abscess'). Granulomas and periapical cysts are usually asymptomatic. Abscesses, however, may result in a persistent fever, a general feeling of being unwell and, when they burst and discharge their contents, halitosis. Acute abscesses may lead to osteomyelitis (bone infection) which in turn may be fatal causing, for example, septicaemia.

A total of five individuals (skulls 3708, 3721, 3735, 3748, 3758) had periapical cavities (5/44, CPR 11.4%, 11/1089 TPR 1%). Skull 3748 had four, skulls 3708, 3721 and 3735 had two, while skull 3758 had one. Possible periapical cavities were found above the upper right premolars of skull 3750, although post-mortem damage made it difficult to be certain. Both teeth were worn well below the cemento-enamel junction with exposure of the pulp cavity. A very small cavity with roughened edges associated with the upper right first incisor of skull 3708 is a possible case and has been counted here.

In four of the above cases the periapical cavities were convincing as abscesses: skull 3735 had two, while skulls 3721 and 3748 had one each. The figures which appear in Table 3.12 are for abscesses only and show that the TPR for Ridgeway Hill is slightly lower than for St John's College, and considerably less than the figures quoted in Roberts and Cox (see Table 3.12).

Periodontal disease and ante-mortem tooth loss (AMTL)

Inflammation of the soft tissues of the jaw (gingivitis, or gum disease) subsequently transfers to the bone (periodontitis). The resulting resorption of bone can expose the roots, leading to ante-mortem tooth loss. Ante-mortem tooth loss may also result from abscess development secondary to caries, periodontal disease secondary to calculus formation, pulp exposure and abscess formation secondary to severe attrition, dental intervention ('pulling' teeth) and trauma. Dental trauma is discussed in a separate section.

Periodontitis was scored using the criteria of Ogden (2005) which assigns a grade one to five, where one is slight and five is severe. A total of 31 individuals (31/44; 70.4%) had the condition, which involved 712 tooth sockets (712/1089; 65.4%). In the majority, the changes were grade 2 (32/44, 72.7%; Fig. 3.12). In twelve they were grade 3 (337/1089; 30.94%) and grade 4 in only one

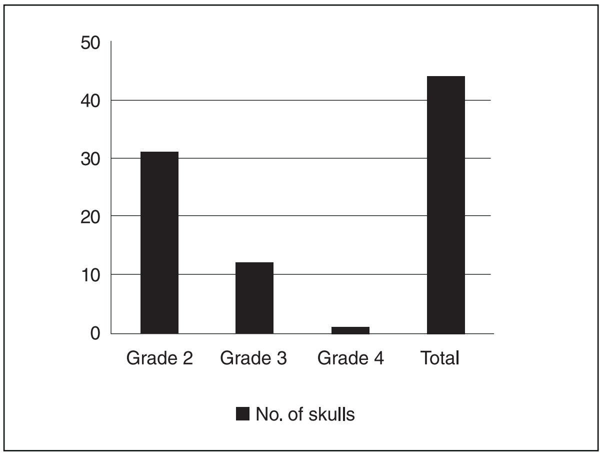


Fig. 3.12 Frequency of periodontal disease by grade

individual (skull 3750), a mature adult male. In this individual a total of 28 tooth spaces were affected (28/1089; 2.57%). At Towton 88% of individuals had some degree of periodontitis: 43% had slight, 35% had moderate and 10% had severe cases (Holst and Coughlan 2000, 82).

A total of seven individuals (skulls 3708, 3721, 3733, 3735, 3746, 3749, 3750) exhibited ante-mortem tooth loss (7/44, CPR 15.9%). With the exception of 3721 and 3750, each of these had lost only one tooth; 3721 had lost two while 3750, who was a mature adult aged 42-45 years, had lost six teeth. The TPR for ante-mortem tooth loss was 13/1089 (1.19%) which is very much lower than the rate of 8% presented by Roberts and Cox (2003, 190-4).

Dental enamel hypoplasia

Dental enamel hypoplasia (DEH) occurs as a result of disruption to the growth of the dental enamel during childhood. The disruption may be the result of numerous factors, childhood illness and malnutrition being among them. Because of its multifactorial aetiology, DEH is generally regarded as a non-specific indicator of physiological stress during childhood (for example, Roberts and Manchester 2005, 76–77). Dental enamel hypoplasia, identified as lines, pits or grooves on the enamel surfaces of the teeth, was observed on six individuals (CPR 13.6%), all on incisors with the exception of one first premolar (skulls 3704, 3706, 3709, 3729, 3750, 3759). In total 14 teeth were involved giving a TPR of 1.3% (14/1079), which is lower than the overall TPR (7.4%) calculated by Roberts and Cox (2003, 187-8).

Abnormal dental attrition

A total of 16 individuals had abnormal patterns of dental attrition (Figures 3.8-3.11 and Fig. 3.13), scored after Brothwell (1981) and Miles (1962). Four of these (3707, 3723, 3729, and 3743) have already been mentioned in the context of age estimation (see above). All abnormal patterns, for all 16 individuals, are summarised in Table 3.13. These generally reflect a trend in which relatively isolated teeth exhibited extreme wear, in marked contrast to other teeth from the same dentition.

The first molars (6s) were the most commonly affected teeth; eight of the 16 dentitions had first molars with advanced wear. Most notable were

Table 3.13 Summary of skeletons with abnormal dental attrition

Skull No.	*Age category*	*Attrition*
3707	Prime adult	Almost cup-like wear on lower left 6 and 8; dentine exposed; distal edge of 8 is concave. Wear on right side is far less marked
3708	Mature adult	Very advanced attrition on all teeth with removal of most enamel. Upper right 6 molar worn below CEJ, almost concave; upper 1s worn below CEJ
3709	Mature adult	Marked attrition on all four 6s
3710	Prime adult	Two polished wear facets on lingual surfaces of right mandibular 1 and 2; left 1 very advanced wear labial surface: the tooth crown is markedly worn down on this plane (vertical?) with associated discolouration
3711	Mature adult	Very marked attrition on all four 6s
3721	Older adult	Extreme diagonal wear (buccal to lingual direction) upper left 6
3722	Young adult	Upper right 6 excessive wear
3723	Adult	Upper left 7 and 8 extreme wear. Far less on the upper left molar
3729	Mature adult	Lower right 8 wear and polishing on occlusal and mesial surfaces; probably related to advanced wear on the lower right 6 and 7 which is almost diagonal and slopes from lingual to buccal. The lower left first and second molar are similarly worn
3735	Mature adult	Extremely advanced molar wear, lower left 6 worn below CEJ
3743	Prime adult	Advanced wear on upper right 6 and the adjacent 5
3744	Prime adult	Wear on upper left 8 is almost cup shaped with advanced exposure of dentine. The pulp cavity is also visible
3750	Mature adult	Upper right 4 and 5 and upper left 3 all very worn below CEJ with exposure of pulp cavity. Upper left 8 has extreme diagonal wear which slopes downwards from buccal to lingual. Additionally, wear on the upper anterior dentition is slightly concave giving a notched appearance
3751	Older adult	Slightly concave wear on upper anterior dentition
3760	Young adult	Two accessory teeth in the maxilla located between the canines and the first premolars which are very worn in a downwards sloping labial to lingual direction
3761	Prime adult	Advanced wear on first mandibular molars, not matched by first maxillary molars

Fig. 3.13 Skull 3709, unusual mandibular wear (arrowed)

Fig. 3.14 Skull 3736, incised horizontal grooves on upper first incisors

skulls 3709 (Fig. 3.13) and 3711 in which all four first molars were affected. This observation has parallels with other, contemporary, assemblages. For example, at St John's College, Oxford the right maxillary first molar of skeleton 1984, a 36-45 year old male, exhibited severe and unusual dental wear (Falys 2010, 51, fig. 2). In this example, the buccal roots were exposed from the alveolar bone and the wear extended onto the entire occlusal surface of the crown, rounding off the usually right angled buccal edge. Like the Ridgeway Hill examples, the isolated nature of the wear suggests that this is probably not normal attrition. Abnormal dental wear on first molars has been seen regularly in Scandinavian assemblages, particularly those from the period AD 900-1100 (Arcini pers. comm.), but the reason is unclear (see below).

Dental modification

A total of six skulls (6/44, CPR 13.6%) showed evidence for dental modification (11 out of 1079 teeth, TPR 1.02%) (see Table 3.14). Skull 3736, a prime adult male is of particular interest. Both upper first incisors had two horizontal grooves which had been deliberately incised into the anterior surfaces of the crowns, with some polishing on the surface (Fig. 3.14). Under magnification, the grooves had well-defined sharp margins, unlike the grooves caused by growth arrest (enamel hypoplasia), which have biological margins. Interpretations for the modifications are discussed below and further in Chapter 5.

The remaining teeth are less convincing examples of deliberate modification. Included is the upper left second incisor of skull 3705 which was worn diagonally from its midline to lateral margin, giving a notched appearance (Fig. 3.15). The first and second maxillary incisors of 3709 also had a notched appearance and the occlusal surfaces had a concave appearance (Fig. 3.16). It has been suggested that the apparent notching of the maxillary first incisors is due to double-shovelling (Arcini pers. comm), a biological trait, identified by the presence of prominent marginal ridges on the labial surfaces (Hillson, 1996, 88).

The first left mandibular incisor of skull 3710 had a polished wear facet on the labial surface (Fig.

Table 3.14 Summary of individuals with dental modification (possible and definite)

Skull No.	Age range	Age category	Sex	No. of teeth affected	Total no. of teeth	TPR (%)
3705	36-44 y	Mature adult	M	1	24	4.2
3709	38-45 y	Mature adult	M	2	29	6.9
3710	26-35 y	Prime adult	M	3	29	10.3
3722	17-18 y	Adolescent/young adult	M	2	31	6.5
3736	25-35 y	Prime adult	M	2	31	6.5
3744	25-30 y	Prime adult	M	1	27	3.7
Total				11	171	6.4

Fig. 3.15 Skull 3705, notched upper left second incisor (arrowed)

Fig. 3.16 Skull 3709, first and second maxillary incisors with subtle notched appearance (arrowed)

3.17), while the upper left second maxillary incisor of skull 3744 had a vertical groove on the labial surface of the crown, with some associated polishing of this surface (Fig. 3.18). Lastly, the upper right first incisor of skull 3722 had a marked notch (Fig. 3.19), while the upper left first incisor had a slight notch. It is conceivable that these last two cases are examples of dental chipping.

Dental trauma

Dental trauma was observed on 34 individuals (34/44, CPR 77.27%) who between them had a total of 103 (TPR 9.5%; 103/1079) teeth affected (Table 3.15). It is argued that in the majority of these, the trauma was probably linked to the act of decapitation, perhaps as a result of forced occlusion caused by the blows to the neck, although other causes (for example, falls and bumps) cannot be completely ruled out. The distribution of dental trauma across all teeth is shown in Table 3.16.

Fig. 3.17 Skull 3710, polished wear facet on first left mandibular incisor (arrowed).

Fig. 3.18 Skull 3744, vertical groove on the crown of the upper left second maxillary incisor (arrowed)

Fig. 3.19 Skull 3722, notched upper right first incisor (arrowed)

A total of 17 individuals had sustained one dental injury, three had two, five had three and seven individuals had between four and eight dental injuries. The greatest amount of dental trauma was evident on two of the skulls: 3751 with 10 injuries and 3723 with 11 injuries. The maxillary dentition was most commonly affected (33 on the right side: 31.7%, 37 on the left side: 35.6%) with with far less involvement of teeth from the mandibular dentition

Table 3.15 Skulls with dental trauma

Skull No.	Age range	Age category	Sex	No. of teeth affected	Total no. of teeth	TPR (%)
3692	30-35 y	Prime adult	M	7	31	22.6
3695	18-24 y	Young adult	M?	1	6	16.7
3705	36-44 y	Mature adult	M	3	24	12.5
3706	18-24 y	Young adult	M	3	31	9.7
3708	35-42 y	Mature adult	M	5	31	16.1
3709	38-45 y	Mature adult	M	6	29	20.7
3711	35-40 y	Mature adult	M	3	31	9.7
3712	35-40 y	Mature adult	M	1	28	3.6
3720	17-18 y	Young adult	M	1	21	4.8
3721	45-52 y	Older adult	M	8	19	42.1
3722	17-18 y	Young adult	M	1	31	3.2
3723	18+ y	Adult	M	11	15	73.3
3724	17-18 y	Young adult	M	1	32	3.1
3725	18-24 y	Young adult	?	1	15	6.7
3726	18-24 y	Young adult	M	1	9	11.1
3728	16-18 y	Young adult	M	1	1	100.0
3729	35-45 y	Mature adult	M	7	28	25.0
3730	17-18 y	Young adult	M	1	26	3.9
3733	18-25 y	Young adult	M	1	28	3.6
3734	18-25 y	Young adult	M	1	18	5.6
3735	42-45 y	Mature adult	M	2	25	0.0
3736	25-35 y	Prime adult	M	3	31	9.7
3738	24-27 y	Prime adult	M	1	29	3.5
3743	25-35 y	Prime adult	M	3	28	10.7
3744	25-30 y	Prime adult	M	7	27	25.9
3747	20-22 y	Young adult	M	1	27	3.7
3748	44-45 y	Mature adult	M	1	24	4.2
3750	42-45 y	Mature adult	M	4	25	16.0
3751	45-50 y	Older adult	M	10	32	31.3
3752	26-35 y	Prime adult	M	1	32	3.1
3757	17-18 y	Adolescent/young adult	M	1	31	3.2
3758	30-35 y	Prime adult	M	2	32	6.3
3759	18-20 y	Young adult	M	2	31	6.5
3760	18-25 y	Young adult	M	1	31	3.2

(18 right side: 17.3%, 16 left side: 15.4%). The upper incisors account for just over a third of the affected teeth (12/33 right side: 36%, 14/37 left side: 37.8%). It is perhaps not surprising that a high number of anterior teeth were affected as these are less well protected that the posterior teeth (Hillson 1996, 319).

Two basic types of dental trauma could be distinguished and these were small chips and/or cracks in the dental enamel and complete crown and/or root fractures. Chips/cracks were the most common and these occurred on the teeth of 33 individuals, which is all of those listed in Table 3.15 with the exception of 3712. Chips/cracks are relatively common in archaeological populations (Mulner and Larsen 1991, 370).

Table 3.16 Number of teeth affected by dental trauma by tooth position (dentition based on the Zsigmondy system – see the key in Chapter 4)

Dentition	Right 8 7 6 5 4 3 2 1	Left 1 2 3 4 5 6 7 8
No. of maxillary teeth with trauma	5 6 2 2 4 2 4 7	5 9 3 3 6 5 3 3
No. of mandibular teeth with trauma	2 2 4 2 4 1 2 1	1 0 2 2 2 0 6 3

Ten individuals had crown and/or root fractures (skulls 3692, 3705, 3709, 3711, 3712, 3721, 3723, 3743, 3744, 3751). Among them were two vertical fractures on the upper right first incisor of skull 3692 and a single unidentified root, and a fracture involving the root of the lower left first premolar of skull 3705. Skull 3709 had a lower right first premolar which has fractured into two pieces in a near vertical plane (Fig. 3.20); the distal root of the lower right third molar had broken off in response to sharp force trauma to the right side of the mandible which had removed a portion of bone extending from the gonial angle to the anterior mandible. In addition, the upper right first and

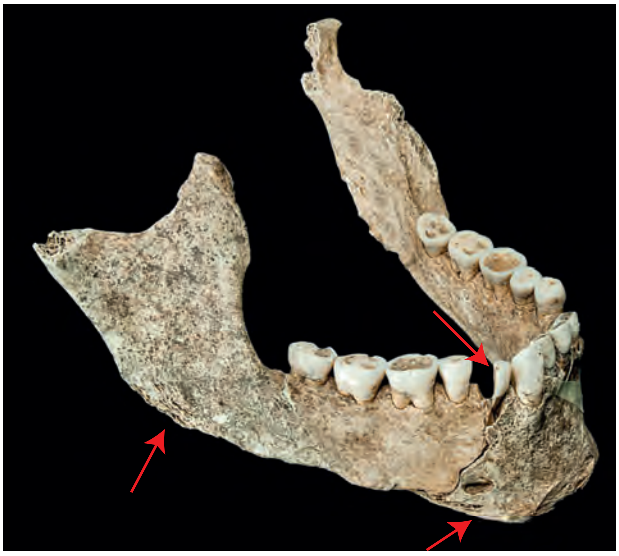


Fig. 3.20 Skull 3709, sharp-force peri-mortem trauma to the right side and anterior of the mandible with fractured lower right first premolar (arrowed)

Fig. 3.22 Skull 3711, sheared upper left first molar crown (arrowed)

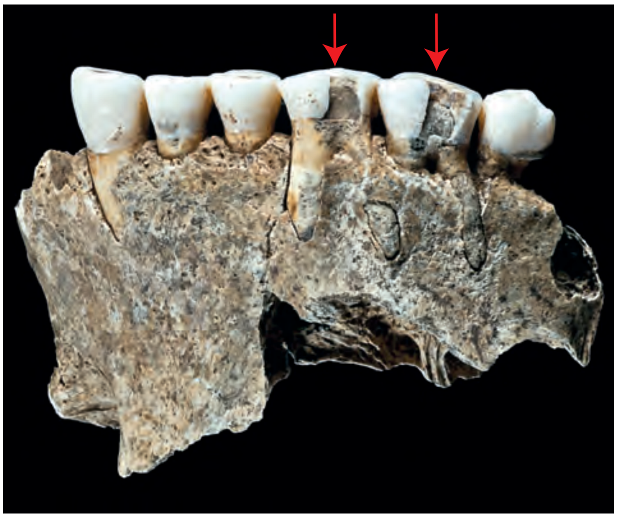


Fig. 3.21 Skull 3709, upper right first and second molars with chipped surfaces (arrowed)

Fig. 3.23 Skull 3712, sheared lower right second molar (arrowed)

second molars had chipped buccal surfaces which are likely to be linked to the same injury (Fig. 3.21). Almost a quarter of the crown of the upper left first molar 3711 had sheared off (Fig 3.22). Skull 3712 had a peri-mortem cut on the right ascending ramus which ran diagonally from the posterior edge upwards. The crown of the second right mandibular molar had sheared off as a result of the impact; a radiating fracture ran from the cut (Fig. 3.23). Skull 3723 had suffered peri-mortem damage which has removed the crowns of the maxillary right 7, 6, 5 and 4 and the maxillary left 2, 3 and 4; the crown of the maxillary left 5 survives, but had broken off post-mortem. Skull 3744 had damage to the roots of the mandibular right first molar (Fig. 3.24). Only the roots of the adjacent premolars had survived, in addition to one third of the crown of the mandibular right canine. The maxillary right second molar had also fractured longitudinally right the way through, probably as a result of peri-mortem trauma. The crown of the maxillary right first premolar of skull 3751 had sheared off from the root (Fig. 3.25).

At Towton, dental trauma was identified amongst 14 individuals, the trauma comprised crown infractions (a crack in the enamel without loss of tooth structure), crown and root fractures, weapon induced cuts, avulsion fractures and post-mortem trauma (Holst and Coughlan 2000, 85). Nine individuals (64%) had sustained only one injury, while the remainder had evidence for at least three. Seven individuals had one or more teeth which showed evidence for crown infractions,

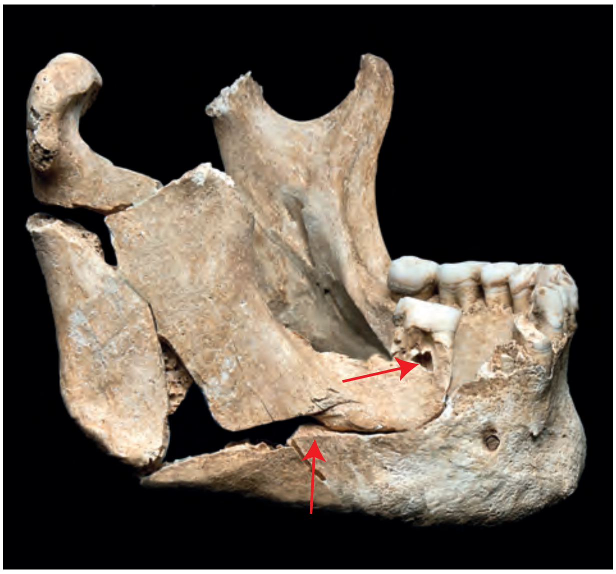


Fig. 3.24 Skull 3744, horizontal cut through right mandible (arrowed) with fractured first molar (arrowed)

Fig. 3.25 Skull 3751, sheared upper right first premolar (arrowed)

including one example (Towton 16), which could be linked to a peri-mortem blunt force injury to the left maxilla (Holst and Coughlan 2000, 85), while the other six appear to have occurred before death. At St John's College seven individuals displayed crown infractions (chipping of the enamel), most commonly on the anterior teeth (Falys 2010, 54).

Ante-mortem pathology and trauma

Evidence for ante-mortem skeletal pathology and trauma was limited to non-specific inflammation (periostitis and sinusitis); joint disease; metabolic disease (*cribra orbitalia*) and neoplastic disease. No ante-mortem trauma was observed.

Non-specific bone inflammation

One individual, skull 3695, exhibited possible periostitis on the right mandibular condyle. Periostitis is fully defined on p. 91, below. It refers to a new layer of bone that is laid down under an inflamed periosteum (the fibrous sheath that covers bone in life) and is identified on the surface of dry bone as porous, layered, new bone.

Another skull (3704) presented changes that were consistent with maxillary sinusitis. Maxillary sinusitis is diagnosed based on the presence of new bone in the nasal sinuses. Upper respiratory tract infections, poor living conditions, environmental pollution, congenital abnormalities, dental disease and specific infectious diseases such as tuberculosis and leprosy are among the aetiological factors associated with this condition (Lewis 2002, 21). In the present skull, the lesion had the appearance of lamellar new bone, indicating that the changes were not active at the time of death. There was no dental pathology on this individual that could have been linked to the changes; periodontal disease was noted, but was minimal and did not concern areas of bone related to the sinus bones.

Joint disease

Changes seen in this category include new bone formation (osteophytosis) and resorption (porosity) on and around joint surfaces and bony contour change. Also included is new bone formation around the margins of the vertebral bodies. These changes are a normal accompaniment to age; in addition they may occur in response to pathology, for example, osteoarthritis and ankylosing spondylitis or trauma.

The changes involved a total of seven individuals (skulls 3696, 3710, 3735, 3736, 3738, 3748, 3749) and are summarised in Table 3.17. The majority of changes were observed on the odontoid joint between the first and second cervical vertebrae. In three of the individuals (skulls 3735, 3738 and 3749) the changes are consistent with osteoarthritis. Osteoarthritis is a disease which affects synovial joints and is diagnosed on dry bone by the presence of eburnation (polishing of bone) and/or at least two of the following: porosity, joint contour change and/or osteophytes (Rogers and Waldron 1995). It is a common disease among modern and archaeological populations, and because it is seen increasingly with the advancement of age, is probably why only limited examples were identified amongst this predominantly young assemblage of skulls. Other aetiological factors besides age are genetic predisposition, sex, trauma and activity (Rogers and Waldron 1995). The three skulls with the disease had a combination of porosity and/or osteophytosis and/or joint contour change and included a young, prime and mature adult.

The osteophytosis and/or porosity observed in association with the other four skulls were not

Table 3.17 Summary of skeletons with joint changes (osteophytosis, porosity and joint contour change)

Skull No.	*Age*	*Changes*
3696	Young adult	Very slight porosity on the odontoid process of CV2
3710	Prime adult	Osteophytosis on the facet for the odontoid on CV1 and the odontoid peg of CV2. Marginal osteophytosis on the inferior body of CV2
3730	Young adult	Some porosity on the left tempero-mandibular joint
3735	Mature adult	Porosity and osteophytosis on the odontoid peg. Porosity (possible) on the left and right sides of CV3 inferior body; osteophytes around the anterior surface of the body of CV3
3736	Prime adult	Very slight osteophytosis anterior surface of the odontoid
3738	Prime adult	Osteophytosis (sizeable) on the odontoid peg with some contour change mainly affecting the left side
3748	Mature adult	Slight osteophytosis on the odontoid peg
3749	Young adult	Slight osteophytosis and some contour change on odontoid peg

accompanied by any obvious signs of pathology or trauma.

Schmorl's nodes

Schmorl's nodes are identified on dry bone as depressions in the end plates of vertebrae. The exact cause of the lesions is unclear and there is some debate as to whether they are caused by a herniation of material from the intervertebral disc (Rogers and Waldron 1995, 27) or whether the herniation of material is secondary to necrosis beneath the end-plate (Peng *et al.* 2003, 879). However, whatever the exact pattern of events in disruption of the vertebral end-plates and herniation of disc material, these nodes have been linked to physical activities (especially in adolescence), such as contact sports (Resnick and Niwayama 1988, 1530) and to acute trauma (Fahey *et al.* 1998). The lower thoracic and upper lumbar vertebrae are most commonly affected in archaeological bone (Rogers and Waldron 1995, 27). A single Schmorl's node was present on the inferior surface of the body of the third cervical vertebra of 3736, a prime adult (CPR: 2%, 1/50; TPR: 0.8%, 1/130).

Cribra orbitalia

Cribra orbitalia is identified on dry bone as surface pitting on the orbital roof (the eye socket), accompanied by thinning of the compact bone (Ponec and Resnick 1984). These lesions have traditionally been attributed to iron deficiency anaemia in which marrow expansion causes diploic hyperplasia (thickening) and resorption of the outer table, which exposes the underlying trabeculae (porosity) (Mays 2012). Iron deficiency anaemia may arise as a result of a number of factors, including a lack of iron in the diet, the inability to absorb the iron in the diet (for example, a lack of vitamin C makes it harder to absorb iron), parasitic infestation in the gut, malaria, and lead poisoning (for example, Stuart-Macadam 1991). However, more recently, Walker *et al.* (2009) have indicated that iron deficiency may not cause bone marrow hyperplasia and suggest that the lesion could relate to a deficiency in vitamin B12 and/or folic acid (megaloblastic anaemia) instead. In addition, unless expansion of the diploic space can be demonstrated, porosity of the orbital roofs may occur in a variety of other conditions, such as rickets or scurvy, which may also lead to thickening of the cranial bones, although not through marrow hyperplasia (Mays 2012, 293). Regardless of aetiology, *cribra orbitalia* is often employed as one of a suite of skeletal indicators (enamel hypoplapsia and periostitis among them) of non-specific health stress, to evaluate the overall burden of disease in archaeological populations (for example, Steckel *et al.* 2009).

The presence or absence of *cribra orbitalia* was scored by employing the criteria defined by Stuart Macadam (ibid.). A total of five individuals (skulls 3686, 3693, 3711, 3731, 3744) had healed *cribra orbitalia* (CPR: 13.5%, 5/37; TPR: left side 11.1%, 3/27; right side 7.1%, 2/28). This is far lower than at St John's College (CPR: 40%, 6/15) (Falys 2010, 49), Towton (CPR: 32%, 9/28) (Coughlan and Holst 2000, 64) and double the combined data in Roberts and Cox (2003, tab. 4.11) (CPR: 7.6%, 404/5334).

Button or ivory osteoma

This is a benign tumour which most commonly occurs on the outer table of the skull, usually on the frontal and parietal bones, although it may also appear on other bones of the skull vault to a lesser extent. It usually presents as mature lamellar bone, circular in shape, raised above the outer table of the cranium and measuring no more than 20mm (Ortner and Putschar 1981, 368).

Skull 3738, a prime adult, had a button osteoma measuring 8mm in diameter on the left parietal, close to the coronal suture. A second tentatively identified osteoma measuring 7mm in diameter was located on the left occipital below the nuchal crest.

Table 3.18 Distribution of sharp force cranial trauma by skeletal element (1 = trauma present; 0 = bone present no trauma; 9 = bone absent) where cranium, mandible, dentition and each cervical vertebrae are considered as separate elements

Skull No.	Age range	Age category	Sex	Cranium	Mandible	Dentition	CV1	CV2	CV3	CV4	CV5	CV6	CV7	Total
3686	18+ y	Adult	M	0	9	9	9	9	9	9	9	9	9	0/1
3692	30-35 y	Prime adult	M	0	0	0	0	0	0	0	0	9	9	0/8
3693	18+ y	Adult	M	1	9	9	9	0	9	9	9	9	9	1 /2
3694	18-25 y	Young adult	M	0	9	0	9	9	1	9	9	9	9	1/3
3695	18-24 y	Young adult	M?	0	0	0	0	0	9	9	9	9	9	0/5
3696	18-25 y	Young adult	?	0	0	0	0	0	9	9	9	9	9	0/5
3704	18-25 y	Young adult	M	1	1	0	0	1	0	9	9	9	9	3/6
3705	36-44 y	Mature adult	M	0	1	1	1	1	1	9	9	9	9	5/6
3706	18-24 y	Young adult	M	0	0	0	0	0	0	0	0	9	9	10/8
3707	25-35 y	Prime adult	M	1	0	0	1	1	0	9	9	9	9	3/6
3708	35-42 y	Mature adult	M	1	1	0	0	1	1	9	9	9	9	4/6
3709	38-45 y	Mature adult	M	0	1	1*	0	1	9	9	9	9	9	3/5
3710	26-35 y	Prime adult	M	0	1	0	1	1	9	9	9	9	9	3/5
3711	35-40 y	Mature adult	M	0	1	0	0	1	1	1	9	9	9	4/7
3712	35-40 y	Mature adult	M	0	1	1	0	1	0	1	9	9	9	4/7
3720	17-18 y	Young adult	M	0	1	0	0	1	9	9	9	9	9	2/5
3721	45-52 y	Older adult	M	0	1	0	0	1	9	9	9	9	9	2/5
3722	17-18 y	Young adult	M	0	1	0	0	1	0	0	1	0	9	3/9
3723	18+ y	Adult	M	1	1	1	9	1	0	1	9	9	9	5/6
3724	17-18 y	Young adult	M	0	0	0	0	9	9	9	9	9	9	0/4
3725	18-24 y	Young adult	?	0	9	0	9	9	9	9	9	9	9	0/2
3726	18-24 y	Young adult	M	0	1	0	1	1	1	1	9	9	9	5/7
3728	18+ y	Young adult	M	1	1	0	0	0	9	9	9	9	9	2/5
3729	35-45 y	Mature adult	M	0	1	0	0	0	0	0	1	9	9	2/8
3730	17-18 y	Young adult	M	1	1	0	1	1	9	9	9	9	9	4/5
3731	18+ y	Adult	M	0	0	9	0	9	9	9	9	9	9	0/3
3732	18+ y	Adult	M	0	0	9	9	9	9	9	9	9	9	0/2
3733	18-25 y	Young adult	M	0	0	0	0	0	1	1	0	9	9	2/8
3734	18-25 y	Young adult	M	0	1	0	0	0	0	9	9	9	9	1/6
3735	42-45 y	Mature adult	M	0	1	0	0	1	0	9	9	9	9	2/6
3736	25-35 y	Prime adult	M	1	1	0	0	1	0	0	0	1	9	4/9
3737	18+ y	Adult	?	0	9	9	9	9	9	9	9	9	9	0/1
3738	24-27 y	Prime adult	M	1	0	0	1	0	0	1	9	9	9	3/7
3739	17-18 y	Young adult	M	0	1	0	9	9	9	9	9	9	9	1/3
3741	18+ y	Adult	M	0	0	9	0	0	9	9	9	9	9	0/4
3742	17-18 y	Young adult	M?	1	1	0	0	1	1	9	9	9	9	4/6
3743	25-35 y	Prime adult	M	0	0	0	0	1	1	9	9	9	9	2/6
3744	25-30 y	Prime adult	M	1	0	1	0	1	1	9	9	9	9	4/6
3746	18-25 y	Young adult	M?	0	0	0	0	0	0	1	1	9	9	2/8
3747	20-22 y	Young adult	M	0	1	0	0	0	0	0	0	1	9	2/9
3748	40-45 y	Mature adult	M	1	1	0	0	1	9	9	9	9	9	3/5
3749	18-25 y	Young adult	M	0	0	0	0	0	1	9	9	9	9	1/6
3750	42-45 y	Mature adult	M	0	1	0	0	0	1	9	9	9	9	2/6
3751	45-50 y	Older adult	M	0	1	1	1	1	0	1	9	9	9	5/7
3752	26-35 y	Prime adult	M	0	1	0	0	9	9	9	9	9	9	1/4
3757	17-18 y	Young adult	M	0	1	0	0	0	1	1	9	9	9	3/7
3758	30-35 y	Prime adult	M	0	0	0	1	1	1	1	9	9	9	4/7
3759	18-20 y	Young adult	M?	1	1	0	1	0	1	9	9	9	9	4/6
3760	18-25 y	Young adult	M	0	0	1	0	0	1	9	9	9	9	2/6
3761	25-30 y	Prime adult	M	0	1	0	0	1	9	9	9	9	9	2/5
Total present				50	45	44	42	41	30	16	8	3	0	279
Total affected				12	28	7	9	23	15	10	3	2	0	109
TPR %				24	62.2	15.9%	21.4	56.1	48.4	58.8	33.3	50	0	39.1

* = peri-mortem radiating fracture

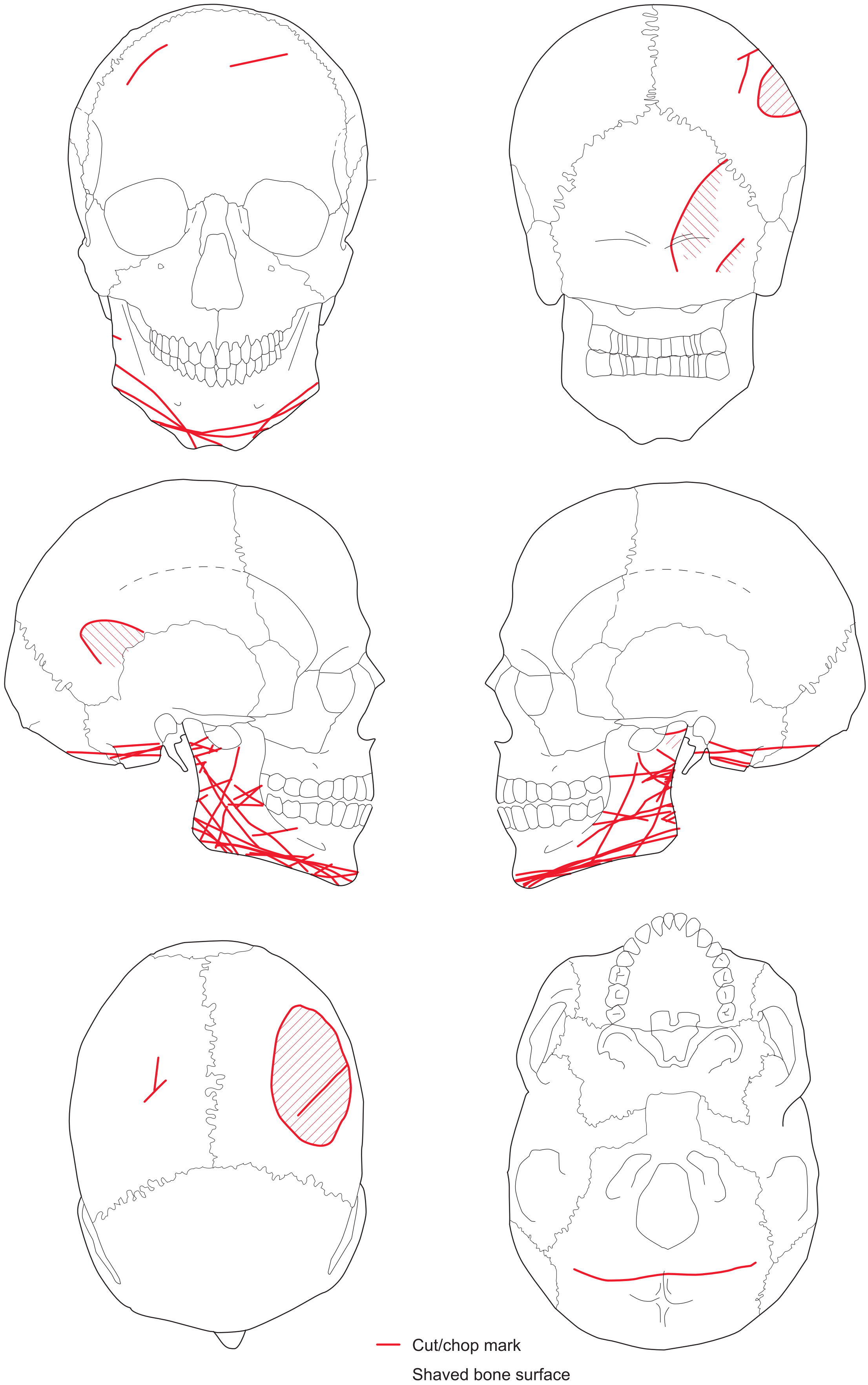


Fig. 3.26 *Distribution of peri-mortem sharp force trauma to the skull (excluding dental and cervical vertebra trauma)*

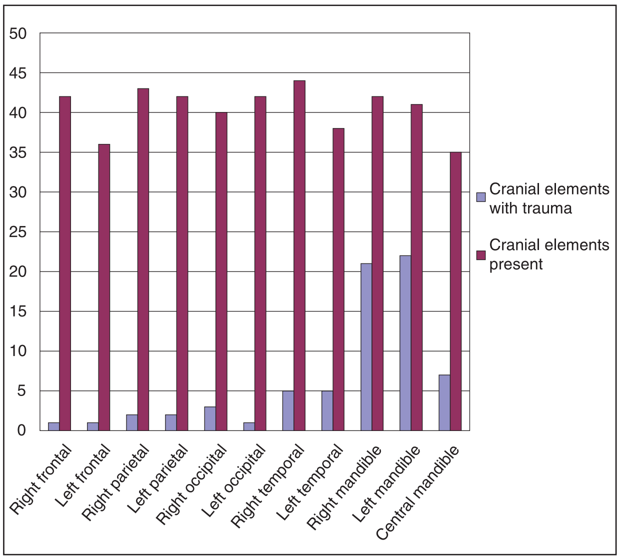


Fig. 3.27 Cranial elements with peri-mortem trauma

Peri-mortem trauma

A total of 39 skulls exhibited peri-mortem trauma. This total rises to 44 if those individuals with evidence of dental trauma only are included (skulls 3692, 3695, 3706, 3724, 3725). The fact that six individuals (skulls 3686, 3696, 3731, 3732, 3737, 3741) do not exhibit any cranial peri-mortem trauma can be explained in part by damage to the deposit by the mechanical excavator when the pit was discovered. All of the trauma was the result of sharp-force or bladed injuries and virtually all of it can be linked directly to the act of decapitation.

The distribution of sharp force trauma by skeletal element (cranium, mandible, CV1-7, dentition) for each individual is detailed in Table 3.18 below. Figures 3.26 and 3.27 show the overall distribution of sharp force trauma to the skull (excluding teeth). Every individual injury is described in detail in the catalogue, thus only assemblage-wide trends and selected case studies are discussed in this section.

Minimum number of injuries

Individuals had sustained between one and seven blows each to their skulls and cervical vertebrae (Table 3.19). A total of 30 (76.92%, 30/39) individuals had received more than one blow (Table 3.18). These are minimum numbers because they do not account for peri- and post-mortem bone loss. This suggests an average of approximately 2.87 blows per individual to the head and neck region, based on a minimum total number of 112 blows (112/39). This figure is lower than Towton where there were between one and 13 cranial wounds, with an average of 4.2 per individual (Novak 2000, 95). At St John's College a total of 40 blade wounds were recorded on 18 crania with individuals exhibiting up to 9 blade wounds with an average of 2.2 injuries per skull (Falys 2010, 57). It must be emphasised that the data for Ridgeway Hill amalgamates skull and cervical vertebrae data.

Minimum number of elements affected

The number of cranial and vertebral elements affected by sharp force peri-mortem ranged from between one and six (counting the dentition as a single element; Table 3.20). This is a minimum number because it does not account for missing elements. In nine cases a single element was affected only (skulls 3692, 3693, 3694, 3695, 3706, 3724, 3725, 3739, 3749), while in one case (3726) six elements were affected by a minimum of four blows. Obviously, a single blow could affect multiple skeletal elements.

Location

The distribution of sharp force wounds (Table 3.21) shows that cranial bones were infrequently affected and that the right and left temporal bones account for most of these. This is in marked contrast to the mandible. For the purposes of analysis each mandible was divided into left (20%, 21/42) and right (53.7%, 22/41) and anterior portions (20%, 7/35). These

Table 3.19 Minimum number of blows inflicted per individual. These figures exclude dental trauma

No. of blows (excluding dental trauma)	*No. of individuals affected*	*Skull No.*
0	11 (22%)	3686, 3692, 3695, 3696, 3706, 3724, 3725, 3731, 3732, 3737, 3741
1	9 (18%)	3693, 3709, 3720, 3721, 3734, 3735, 3739, 3749, 3760
2	10 (20%)	3694, 3708, 3710, 3729, 3733, 3746, 3747, 3748, 3750, 3761
3	5 (10%)	3728, 3736, 3743, 3752, 3758
4	10 (20%)	3705, 3707, 3711, 3712, 3723, 3726, 3744, 3751, 3757, 3759
5	3 (6%)	3704, 3730, 3738
6	1 (2%)	3742
7	1 (2%)	3722

Table 3.20 Number of elements affected by sharp force trauma.

No. of blows (excluding dental trauma)	*No. of individuals affected*	*Skull no.*
0	6 (12%)	3686, 3696, 3731, 3732, 3737, 3741
1	9 (18%)	3692, 3693, 3694, 3695, 3706, 3724, 3725, 3739, 3749
2	5 (10%)	3734, 3746, 3752, 3760, 3761
3	13 (26%)	3704, 3707, 3709, 3720, 3721, 3728, 3729, 3733, 3735, 3738, 3743, 3747, 3750
4	10 (20%)	3710, 3712, 3722, 3730, 3736, 3742, 3744, 3748, 3757, 3759
5	6 (12%)	3705, 3708, 3711, 3723, 3751, 3758
6	1 (2%)	3726

*Elements comprise skull, mandible, dentition, CV 1-7. Italics indicate dental trauma only

figures exclude associated radiating fractures. When the Ridgeway Hill sharp force trauma locations are compared with St John's College and Towton differences in the elements affected become apparent: there are fewer injuries to the crania and far more to mandibles and cervical vertebrae.

Directionality

Injuries had been delivered from all directions, but most commonly from behind (55.4%, 62/112) followed by the right side (20.5%, 23/112), the front (15.2%, 17/112) and the left side (8.8%, 10/112) (Tables 3.22 and 3.23). This contrasts with Towton where most injuries had been delivered from the front (36%; 26/82), followed by from behind (32%; 23/82), the left side (18%; 13/82) and the right side (15%; 11/82) (Table 3.22). In 23 of the 30 Ridgeway Hill individuals with more than one injury (76.7%), the blows had been delivered from more than one direction (Table 3.23).

Sharp force trauma not directly associated with decapitation

Only five skulls (3693, 3704, 3736, 3738, 3759) had

Table 3.21 Locations of sharp-force peri-mortem trauma by cranial element (TPR excludes disarticulated material)

	Ridgeway Hill	*%*	*St John's**	*%*	*Towton**	*%*
Right frontal	1/42	2.4				
Left frontal	1/36	2.9				
Frontal			3	7.9	9/28	32.1
Right parietal	2/43	4.7	10	26.3		
Left parietal	2/42	4.8	10	26.3	9/29	31.1
Right occipital	3/40	7.5			8/29	27.6
Left occipital	1/42	2.4				
Occipital			9	23.7	9/28	32.1
Right temporal	5/44	11.4			5/26	19.2
Left temporal	4/38	10.5			5/27	18.5
Right mandible	21/42	50.0	2	5.3		
Left mandible	22/41	53.7	3	7.9		
Central mandible	7/35	20.0	1	2.6		
Mandible					7/27	25.9
CV1	9/42	21.4				
CV2	23/41	56.1				
CV3	15/30	50.0				
CV4	10/16	62.5				
CV5	3/8	37.5				
CV6	2/3	50.0				
CV7	0/0	0.0				
Cervical vertebrae	62/140	44.3	10		9/187	4.8

*Data for individual vertebrae at St John's and Towton not available.

suffered sharp force peri-mortem trauma which was not necessarily directly associated with decapitation. A peri-mortem cut mark was located on the left side of the frontal bone of 3693, close to the coronal suture, and it would have extended into the missing portion of the frontal bone. Two possible radiating fractures were associated and there was also a flake of bone which had partially detached. The cut measured 31mm in length and 0.7mm in depth. It did not not penetrate to the endocranial surface and was angled diagonally from left to right. The posterior side of the cut was straight, while the other was more ragged (Fig. 3.28). These features are consistent with a blow from the front by a right-handed assailant. No other injuries were present although only the frontal, parietal and second cervical vertebrae survived. It is therefore likely that this was a disabling blow and the head was removed below the

Table 3.22 Direction of injuries

Site	*From the front*	*%*	*From the left side*	*%*	*From the right side*	*%*	*From behind*	*%*	*Total*
Ridgeway Hill	17	15.2	10	8.9	23	20.5	62	55.4	112
Towton	26	36	13	18	11	15	23	32	82

Table 3.23 Direction of injuries by individual (n = 39). Includes skulls, mandibles and cervical vertebrae

Skull no.	From the front	From the left side	From the right side	From behind	Total	% of total
3693	1	0	0	0	1	0.9
3694	0	0	2	0	2	1.8
3704	0	2	0	3	5	4.5
3705	0	0	3	1	4	3.6
3707	0	0	1	3	4	3.6
3708	0	0	1	1	2	1.8
3709	0	0	0	1	1	0.9
3710	0	0	0	2	2	1.8
3711	0	0	0	4	4	3.6
3712	0	1	2	1	4	3.6
3720	0	0	0	1	1	0.9
3721	0	0	0	1	1	0.9
3722	3	1	0	3	7	6.3
3723	2	1	0	1	4	3.6
3726	0	0	0	4	4	3.6
3728	0	0	0	3	3	2.7
3729	0	1	0	1	2	1.8
3730	1	1	0	3	5	4.5
3733	1	1	0	0	2	1.8
3734	0	0	0	1	1	0.9
3735	0	0	0	1	1	0.9
3736	1	0	0	2	3	2.7
3738	0	1	4	0	5	4.5
3739	0	0	0	1	1	0.9
3742	0	0	1	5	6	5.4
3743	3	0	0	0	3	2.7
3744	0	0	2	2	4	3.6
3746	0	0	2	0	2	1.8
3747	1	0	0	1	2	1.8
3748	0	0	1	1	2	1.8
3749	0	0	0	1	1	0.9
3750	0	1	0	1	2	1.8
3751	0	0	1	3	4	3.6
3752	0	0	0	3	3	2.7
3757	2	0	1	1	4	3.6
3758	0	0	1	2	3	2.7
3759	1	0	1	2	4	3.6
3760	0	0	0	1	1	0.9
3761	1	0	0	1	2	1.8
Total	17	10	23	62	112	

level of the second cervical vertebra.

Skull 3704 had a cut on the left parietal measuring 34.1mm in length and 1.5mm in width (Fig. 3.29). The cut was aligned diagonally and had a smooth anterior margin and a more ragged posterior margin with two flaked areas. This is probably the result of a shallow glancing blow from the left which did not penetrate the endocranial surface. This injury is very similar in appearance to that on the left frontal of skull 3693. There appear to be at least two fine striations running parallel to this cut which may relate to imperfections in the blade used. The mandible and the second cervical vertebrae exhibited sharp force peri-mortem injuries directly linked to decapitation. A minimum of five blows were identified.

Fig. 3.28 Skull 3693, sharp-force peri-mortem cut mark on left side of frontal bone (arrowed). Top: antero-lateral view; bottom: posterior view

Skull 3736 had sharp force trauma on the right frontal bone, immediately anterior to the coronal suture. The cut was bevelled with a slightly polished upper edge. Only part of the injured area was present. The surviving portion measured 31.6mm in length (Fig. 3.30). There was also evidence for dental trauma and sharp force peri-mortem injuries to the mandible, the second and sixth cervical vertebrae. A minimum of three blows had been inflicted.

Skull 3738, a prime adult male, had sustained no less than four injuries to the cranium which were not directly related to the process of decapitation. The injuries are numbered 1-4 to facilitate descrip-

Fig. 3.29 Skull 3704, sharp-force peri-mortem cut on the left parietal (arrowed). Top: from the left side; middle: from above; bottom: left, supero-lateral view

tion, but are not an indication of the sequence in which the injuries were inflicted, although the third injury was clearly inflicted after the second. Injury 1 was located on the left parietal; a large scoop of bone measuring 68.7mm (inferior-superior) and 45.7mm (posterior to anterior) was probably removed by a blow from the left. The upper edge of the injury was smooth and highly polished while

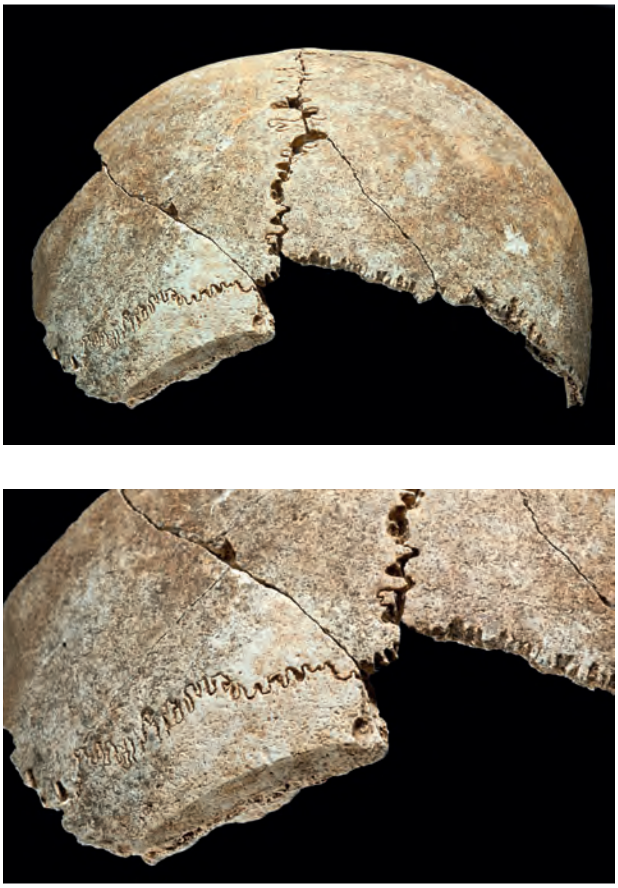


Fig. 3.30 Skull 3736, fully penetrating sharp force wound on the right frontal bone, just anterior to the coronal suture (anterior view)

there was some flaking of bone on the inferior ragged margin. The blow made contact, completely penetrating through the endocranial surface and removing a roundel of bone. Post-mortem damage is probably masking radiating fractures (Fig. 3.31). This injury would have caused immediate and severe trauma to the brain and would have certainly incapacitated the individual.

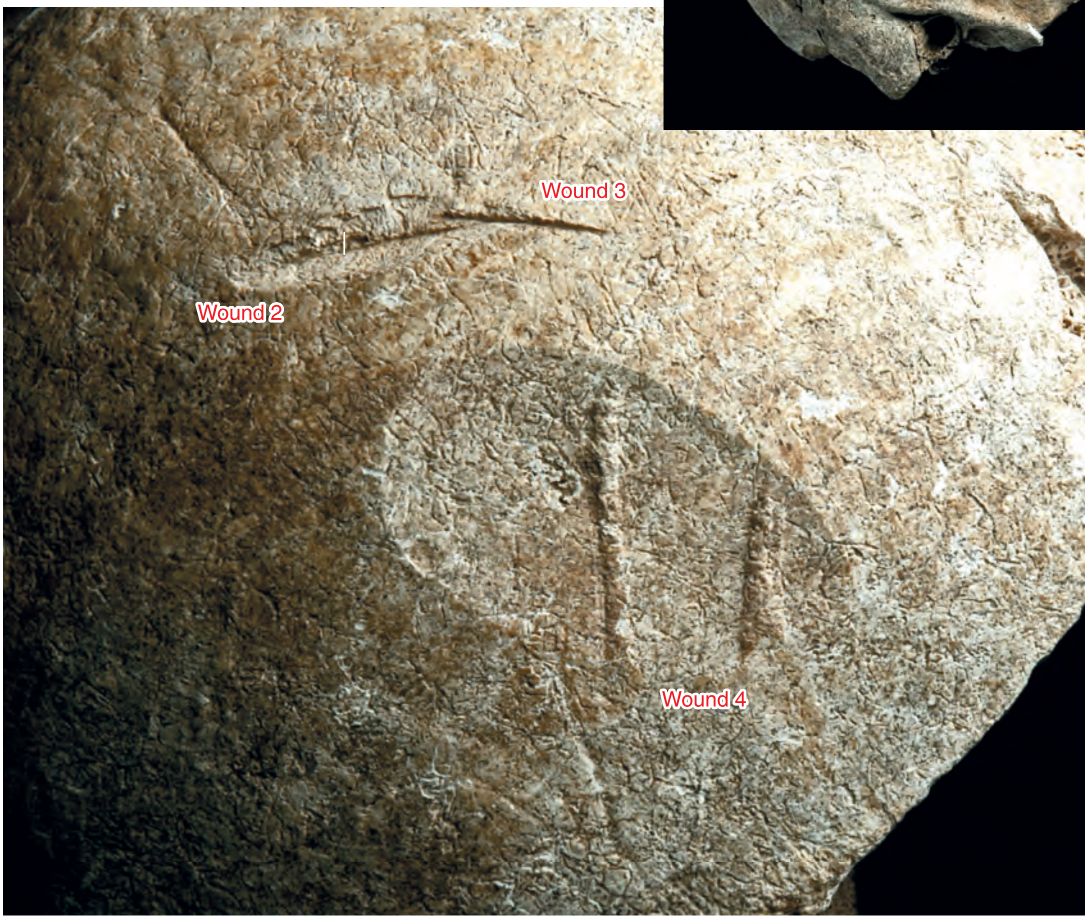
A further two injuries (2 and 3), located on the right parietal, comprised two glancing blows to the ectocranial surface which did not penetrated the diplöe. The larger of the two measured 27.7 x 22mm; the second shorter cut was located anteriorly and diagonal to the first. The latter is a classic skip lesion with a smooth edge on the oblique surface and flakes on the acute edge where the blade was halted by its contact with the bone (Fig. 3.32). Blow 3 was inflicted after blow 2.

A fourth injury was located on the right parietal below injury 2 and was an egg-shaped glancing blow measuring 35.3 x 20.5mm which had polished the surface of the skull. The wound was very shallow with a slightly scooped appearance and it had not quite penetrated the diplöe. There were two slight ridges running parallel to one another and

Fig. 3.31 Skull 3738, large sharp force scoop lesion on the left parietal bone (wound 1). Top left: from the left side; top right: anterior view; bottom left: supero-lateral view; bottom right: from above

from superior to inferior across the injury, which could relate to imperfections in the blade used (visible in Fig. 3.32). Similar ridges appear on an injury to the left mastoid of a Roman decapitation (skeleton 1118) from Little Keep, Dorset (McKinley 2009, 34, plate 6). This was an adult male aged 40–50 years and, in contrast to skull 3738, the injury was thought to directly relate to the act of decapitation. Also similar to 3738 are the striations that have been microscopically analysed on the left parietal and left temporal bone of burial 1487 from St Andrew's, Fishergate, York, thought to be the result of small defects in the weapon edge and indicative of the direction of the blows (Stroud and Kemp 1993, 235, fig. 74 b and c). In addition at Heronbridge, skeleton 1 had a shallow, bladed injury located on the right parietal, just behind the ear, the upper limit of which was clearly defined by a relatively deep horizontal line, from which vertical lines of irregular length emanated downwards, almost in a comb-like manner, but irregularly spaced (Holst 2009, 9, plate 8). The appearance of this injury suggests that a bladed weapon, with a worn, irregular, edge had been used to deal a glancing blow to the right side of the head, almost parallel to the side of the head. It is probable that this was carried out with the handle end of a sword or dagger blade. Whether this was a failed attack on the head, or was done in a deliberate fashion could not be established.

Fig. 3.32 Skull 3738, linear (wounds 2 and 3) and egg-shaped (wound 4) glancing blow on the right parietal bone (views from the right side). Note the raised striations on wound 4, possibly relating to blade imperfections



Injuries 1, 2 and 4 described above fall into Boylston's (2004, 40) third category of sharp force trauma in which 'the weapon has...made contact and produced a deeper wound (sometimes removing a roundel of bone which may traverse both outer and inner tables or just penetrate the diplöe)', while injury 3 is a comparatively superficial lesion where the weapon has merely created a skip lesion as it glanced off the bone. The diagnostic criteria for the former include a linear wound with a well defined clean edge, a flat, smooth, polished cut surface on the oblique side of the injury, flaking and roughening on the acute side, and, sometimes, terminal fractures (Boylston 2004, 40).

Injury 1 is very similar to the pseudo-trephination observed on the Maiden Castle Saxon skeleton, Q1, referred to as 'cut b' by Brothwell (1971). Brothwell concluded that the lesion was more likely to have been caused by a sword than an axe (see Chapter 1).

A close parallel for injuries 2, 3 and 4 sustained by skull 3738 can be found at the cemetery of Addingham, Wharfedale, West Yorkshire, which has a calibrated radiocarbon date range from the 8th to the 11th century (Adams 1997, 151). Burial A105 included fragments from three skulls: that of a male (A105) and fragments from a thinner skull that matched fragments found in context A62. The latter was composed of two possibly female skeletons. One of these females had sustained numerous blows from a very sharp, straight-edged weapon. The blows were mainly visible on the left parietal and would thus have been delivered by a right-handed person from the front, or a left-handed person from the back. One blow had taken a super-

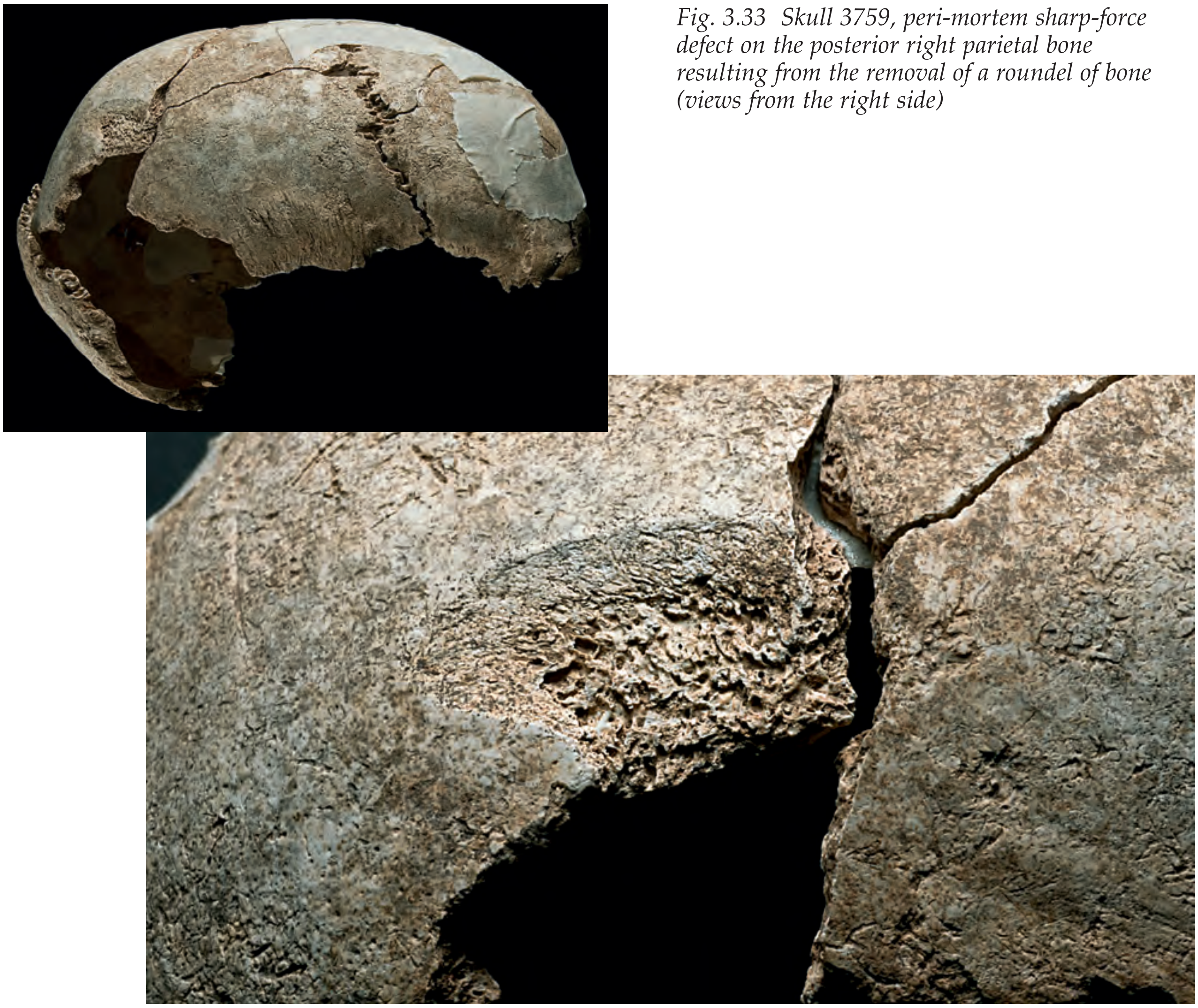


Fig. 3.33 Skull 3759, peri-mortem sharp-force defect on the posterior right parietal bone resulting from the removal of a roundel of bone (views from the right side)

ficial slice out of the bone. The final thrust appeared to have been made when the individual was on the ground. These injuries would not have been survivable and, indeed, no evidence of healing was found (Boylston and Roberts 1997, 178). Injuries 2-4 on skull 3738 involved the right parietal, so could have been delivered by a left-handed assailant from the front or a right-handed one from behind. However, injury 1, which removed a large roundel of bone, was located on the left parietal and may suggest that there was more than one assailant. The injuries to the Addingham skull are illustrated elsewhere (Boylston 2004, 40, fig. 15). The relatively equal distribution of the sexes and the presence of children among the burials at Addingham suggests that the cemetery was serving a normal rural community and not a particular group of individuals such as a single-sex monastic community or a war cemetery (ibid, 179). As such the reasons for this woman's fatal injuries can only be guessed at.

Skull 3759 had an injury to the right posterior parietal, adjacent to the temporal which had removed a roundel of bone. The diplöe was exposed, but the injury did not penetrate to the endocranial surface. It measured 29.8 x 14.6mm and there was polishing on the bevelled upper edge of the wound. Part of the affected area was missing (Fig. 3.33). This individual had also received injuries to the mandible and the first and third cervical vertebrae. A minimum of four blows had been inflicted.

Sharp force trauma associated with decapitation

A total of 39 out of 50 (78%) individuals exhibited evidence for peri-mortem sharp-force trauma associated with decapitation. Crania, mandibles and cervical vertebrae were all involved (see Table 3.21).

Taking the crania only, 26% (13 out of 50) had sharp force injuries. Five of these (skulls 3693, 3704, 3736, 3738, 3759) have already been discussed above, as their injuries may not directly relate to decapitation. The remaining eight (skulls 3707, 3708, 3723, 3728, 3730, 3742, 3744, 3748) exhibited peri-mortem sharp force trauma that was unequivocally linked to

Fig. 3.34 *Skull 3728, sharp-force peri-mortem trauma to right mastoid process (view from the posterior)*

removal of the head. Most cranial lesions were observed on the temporal bones, followed by the occipital bones (Table 3.21). In three cases the left temporal was affected (skulls 3707, 3708, 3730), in a further four the right temporal was affected (skulls 3723, 3728, 3742, 3744) (Fig. 3.34), while injuries were observed on both the left and right temporal bones of skull 3748. This skull is discussed in more detail below. Only three skulls had peri-mortem sharp force injuries involving the occipital bone (3707 – right side, 3735 – right side, 3748 – left and right sides).

Sharp force injuries involving the mandible were markedly more frequent than crania, involving a total of 28 out of the 45 that had survived (62.2%) (Figs 3.35 – 3.37). For the purposes of this analysis each mandible was divided into left (TPR: 50%, 21/42), right (TPR: 53.7%, 22/41) and anterior portions (TPR: 20%, 7/35). These figures exclude associated radiating fractures.

Out of 140 surviving vertebrae, 62 had evidence of sharp force peri-mortem trauma (TPR 44.3%)

Fig. 3.35 *Skulls 3711, sharp-force peri-mortem trauma to mandible (arrowed) with similar lesions to those described by Berg (2008)*

Fig. 3.36 *Skulls 3750, sharp-force peri-mortem trauma to mandible (arrowed)*

Fig. 3.37 Skull 3759, sharp-force peri-mortem trauma to mandible (arrowed)

Fig. 3.39 Skull 3742, multiple cuts to the axis (anterior view)

Fig. 3.38 Skull 3742, sharp-force peri-mortem trauma on posterior body of C2 (superior view)

Fig. 3.40 Skull 3743, incision on anterior body of C2 (anterior view)

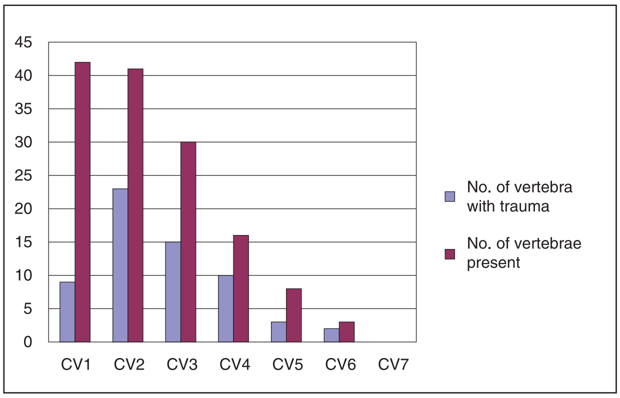


Fig. 3.41 Number of vertebrae with sharp force peri-mortem trauma

(Figs 3.38–3.42). The most commonly affected vertebra was the second (23/41, TPR 56.1%), followed by the fourth (10/16, TPR 62.5%), the sixth (2/3, TPR 66.6%), the third (15/30, TPR 50%), the fifth (3/8, TPR 37.5%) and the first (9/42, TPR 21.4%). In seven cases (skulls 3694, 3733, 3743, 3746, 3749, 3758, 3760) vertebrae were affected by sharp force trauma without any involvement of the mandible or cranium.

A few parallels with other assemblages are worth mentioning here. At St Andrew's, Fishergate an injury to the left mastoid of burial 1487 is paralleled by Ridgeway Hill skulls 3707, 3708, 3723, 3728, 3730, 3742 and 3744 which had cuts to either the right side

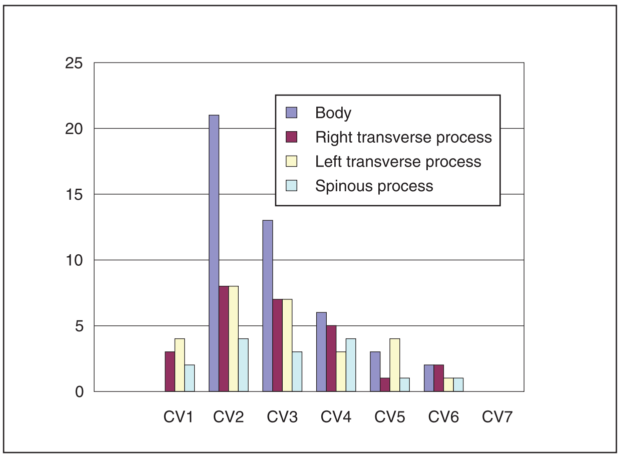


Fig. 3.42 Vertebral elements affected by peri-mortem trauma

(four examples) or the left side (four examples). Skull 3748 had injuries to both sides, which are thought to have been caused by a single blow from behind. This example is also similar to cut f identified on the skull of Q1 from Maiden Castle (Brothwell 1971). Cut f was a large and very straight cut, across the base of the skull and was, according to Brothwell, likely to have been delivered whilst the victim was lying with the back of their head placed upwards (Brothwell 1971, 234–5). The length of the cut suggested that a sword rather than an axe had been used, because it had been created by a cutting edge greater than 110mm (ibid., 236).

In addition to these examples, injuries observed on some cervical vertebrae, which were fine incisions and had been delivered from the front, parallel those observed on Skeleton 7 from Walkington. This skeleton had two parallel cut marks on the superior aspect of body and articular facets of the first thoracic vertebra, delivered from the front and consistent with blood letting, throat slitting or decapitation from the front (Buckberry and Hadley 2008, 155, fig. 9.3). Ridgeway Hill examples include a fine, horizontal incision on the right side of the anterior body of the second cervical vertebra of skull 3743 which extends from the right side to the centre of the anterior surface and was definitely caused by an attack from the front (Fig. 3.40). On a further individual, the second cervical vertebra of skull 3742 had three cut marks, including one which ran diagonally across the posterior upper body (Fig. 3.39). It is a fine incision which does not penetrate far into the body, suggesting it had been made by a thin bladed weapon such as a fine sword or a knife.

Injuries sustained to base of the mandibular bodies from skulls 3709 (Fig. 3.20), 3710, 3711, 3739, 3742, 3748, 3750 and 3752 are similar to two examples from Walkington Wold (Buckberry and Hadley 2008). The first of these (Skeleton 11) was observed on the base of the mandibular body. The posterior portion of the mandible was not present and it is likely that the fracture was radiating from areas of sharp force trauma to the inferior portion of the ascending ramus. The blow had been delivered from behind and is consistent with decapitation. The dens of the second cervical vertebra also appeared to have been removed by this blow. In addition, the 'skull associated with skeleton 1' at Walkington Wold had sharp force trauma along the base of the mandibular body with radiating fractures towards the chin (ibid., 159–160, fig 9.5a). There was no evidence of any injury to the poorly preserved cervical vertebrae. These, and the Ridgeway Hill examples, are consistent with blows delivered from behind by a heavy weapon such as a sword or an axe.

Lastly, it is worth noting that defects observed on the mandibles of skulls 3711 (Fig. 3.35), 3742, 3747, 3750 and 3757 were similar to those observed in association with sharp force trauma, probably by a machete, on the mandibles of victims executed by the Khmer Rouge regime at the Tuol Seng prison in Phnom Penh and subsequently disposed of in the killing field of Choeungk Ek between 1975 and 1979 (Berg 2008). The defect is a 'peeled' lesion where the lingual surface of the mandibular body has been removed, exposing the tooth sockets, although leaving the buccal surface intact (Berg 2008, 315-318). The peeled areas were usually triangular in shape (apex towards the mandibular midline) and fractures radiated from the apex of the peeled area towards the mental spines. A completely missing ascending ramus often accompanied this trauma manifestation. This defect is believed to be due to the method in which the weapon was removed from the bone. If insufficient force was applied to the weapon to completely decapitate the individual, or if the individual was positioned with their head down and their mandible near the chest, the weapon could lodge in the stronger structures of the bone (i.e. the ascending ramus). To free the weapon, a sharp twist would probably need to be applied. The rotational forces applied would free the blade and, at the same time, peel the surface on which the force was applied.

Overall patterns of decapitation

The overall patterns of decapitation can be described as follows. The majority of injuries were consistent with heavy chopping blows, consistent with hacking trauma. This was performed from all directions (front, back, left and right sides). In many cases multiple blows had been delivered to remove the head. This suggests that in most cases the neck region was first wounded and then the head was severed, usually from behind (Fig. 3.43). Some heads appear to have been removed high up on the cervical spine (at the level of CV1-CV3) indicating

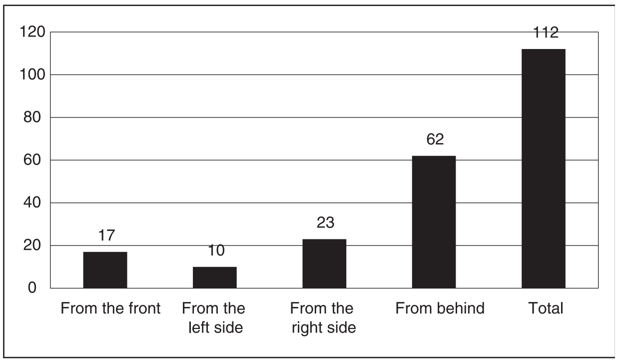


Fig. 3.43 Direction of blows causing sharp force trauma

that the neck had been hyper-extended (examples include skulls 3704, 3705, 3707, 3708, 3709, 3710, 3720, 3721, 3730, 3735, 3736, 3742, 3743, 3744, 3748, 3749, 3750, 3759, 3760, 3761), while others were associated with blows to lower cervical vertebrae. Among them were three skulls from heads which had been severed at the level of the fifth cervical vertebra (skulls 3722, 3729, 3746). In two cases, the sixth cervical vertebra was affected by peri-mortem sharp force trauma (skulls 3736, 3747) and a further four cases were found among the post-cranial material (skeletons 3753, 3803, 3804, 3810). In addition, although there were no seventh cervical vertebrae in association with skulls, out of 34 that had survived with the skeletons, two had sustained fully penetrating sharp force trauma.

Fig. 3.44 Skull 3748, sharp-force peri-mortem trauma to occipital, posterior view

Skull 3748 is interesting as it may demonstrate an example of an 'efficient' decapitation rather than a 'botched' one. A single blow at a near horizontal angle travelling from posterior to anterior has sliced through the occipital bone immediately below the external occipital crest/inferior nuchal crest producing a wound with a smooth and bevelled superior edge; the inferior edge is more ragged and there is a flaked portion of bone located centrally (Fig. 3.44). The blow continued through the left and right temporal bones removing both mastoid processes. The cut is very clean on the right side with some polishing with an associated vertical nick at the anterior end of the cut. The cut on the left side is not as clean and stops at a ragged nub of bone. The trajectory of the blow continued through the mandible removing the anterior/inferior portion which has survived in two fragments and has a polished appearance. Some post-mortem erosion is also present. The right gonial angle is missing and there are two vertical radiating fractures, one located between the mandibular first and second molars and the second in the region of the left mandibular first molar. A second blow probably from the right side has removed part of the anterior and right body of CV2 along with a small part of the right facet and arch. It seems certain that the first blow would have killed the individual while the second was intended to sever the head from the body.

THE INFRA-CRANIAL SKELETONS

by Louise Loe and Helen Webb

Quantification

A total of 65 context numbers was assigned to the post-cranial remains, which comprised complete, or almost complete skeletons, partial skeletons and isolated limbs and extremities. Complete skeletons equate to 17 discrete articulated individuals that had not been damaged by the mechanical excavator. Partial skeletons, totalling 23, were also discrete articulated individuals, but these had lost bones/skeletal regions as a result of machine disturbance. Lastly, 25 were isolated limbs and extremities which comprised parts of skeletons disturbed by the mechanical excavator.

Re-association exercise

Attempts were made to re-associate bones with reference to the site plan and context records and by taking into account age, size, morphology and colour (White 1992). A total of three re-associations were made: partial skeleton 3783 with right arm 3766; right leg 3792 with left foot 3797 and partial skeleton 3805 with left femur 3807 and left tibia and foot 3808 (these are referred to as skeletons 3783, 3792 and 3805 hereon). Thus, the revised number of contexts is 61: 17 complete skeletons, 23 partial skeletons and 21 isolated limbs and extremities.

In this report complete and partial skeletons are considered together (40 discrete skeletons in total). The related limbs and extremities are treated separately.

Number of individuals

The minimum number of individuals (MNI) count and the most likely number of individuals (MLNI) count were employed to estimate the number of individuals. These are described above and discussed at the end of this chapter. All post-cranial remains – complete skeletons, partial skeletons, isolated limbs and extremities and all disarticulated post-cranial material (3681 and 3685) – were included in these estimates (see Table 3.24).

In the present assemblage the distal right femur was the most frequently occurring element and indicates a minimum number of 46 individuals. Estimation of the MLNI employed the proximal femur, the most frequently occurring paired element in the present assemblage. For the disarticulated bones, pairs were determined visually and took into account general size, robusticity, morphological variation, the presence/absence of fusion lines, and non-metric traits (Buikstra and Ubelaker 1994). Pathological bones, and those proximal femurs that were very incomplete, were not considered for pairing. Only pairings that were highly likely were considered for the MLNI calculation. This resulted in a total of five pairs being identified, which was added to the total number (31) of paired proximal femurs within the articulated assemblage. The estimated MLNI was 52.

Preservation

A total of 20/40 skeletons (50%) were classified as being between 76% and 100% complete. Most of these individuals were represented by approximately 80% of an entire post-cranial skeleton. Of the remainder, 20 were between 51% and 75% complete; 25 between 25% and 50% complete; and five, less than 25% complete. All isolated limbs and extremities comprised less than 25% of a complete skeleton (Fig. 3.45).

The condition of bone surfaces was, for the majority, excellent. That is, over 60% of all post-cranial skeletons were judged to be uneroded or have some patchy erosion (categories one and two after McKinley 2004, 16). Only six skeletons (one complete skeleton, two partial skeletons and two lower limbs/extremities) were judged to have more extensive surface erosion,

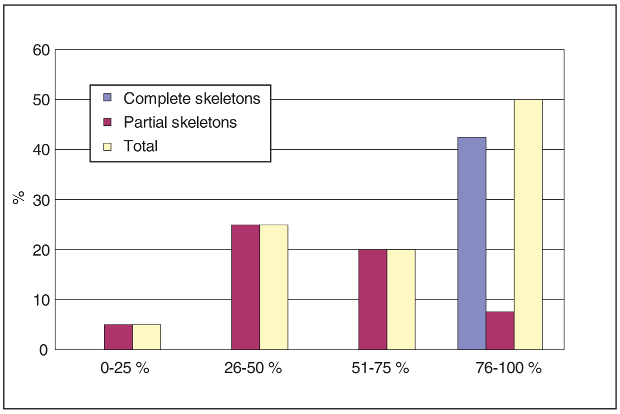


Fig. 3.45 Completeness of discrete articulated skeletons (N=40)

Table 3.24 Numbers of elements employed in MNI and MLNI counts

Element	*Disarticulated bone 3681 and 3685*		*Isolated limbs/extremities*		*Discrete skeletons*		*Total no. of pairs*
	Right	*Left*	*Right*	*Left*	*Right*	*Left*	
Distal humerus	7	6	2	0	30	29	29
Proximal radius	7	6	2	0	30	26	26
Distal radius	4	7	4	1	32	25	25
Proximal ulna	8	10	2	0	32	26	26
Distal ulna	3	6	4	1	32	25	25
Proximal femur	10	11	2	1	33	31	31
Distal femur	11	9	3	3	32	30	30
Proximal tibia	5	12	4	3	30	28	28
Distal tibia	7	6	2	2	29	29	29
Distal fibula	3	4	2	2	28	29	28

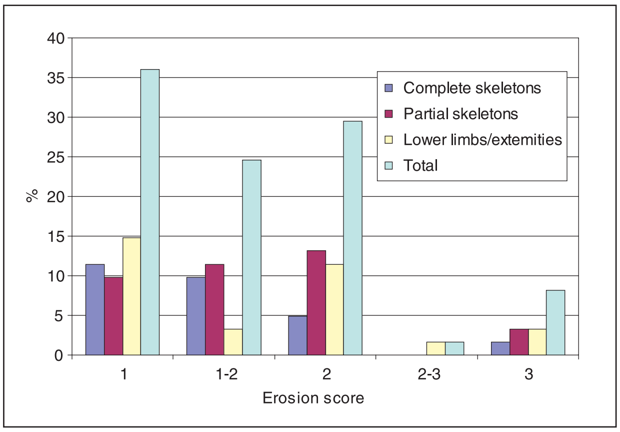


Fig. 3.46 Bone surface condition of all infra-cranial skeletons (N=61) (after McKinley 2004, 16)

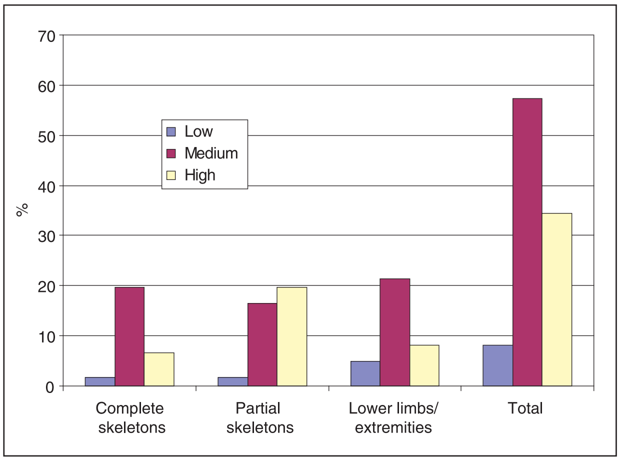


Fig. 3.47 Fragmentation of all infra-cranial skeletons (N=61)

consistent with McKinley's grade three (2004, 16). This grade falls in the middle of McKinley's scoring system, which comprises six categories, where six refers to extremely bad surface erosion. Thus, even the remains with the highest condition score were still well preserved (Fig. 3.46). No bleaching or evidence for scavenging was observed.

Most skeletons had suffered medium levels of fragmentation and a significant number, high levels (Fig. 3.47). Overwhelmingly, this was due to post-mortem processes (for example, cracking and subsequent fragmentation as bone dried out and/or pressure from overlying soil), particularly where long bones and regions of the thorax and pelvis were concerned. A smaller proportion were a result of peri-mortem trauma, particularly in the case of cervical vertebrae, scapulae and clavicles.

Demography

It was possible to estimate the sex of 36 discrete skeletons, all of whom were judged to have been male (Table 3.25, Fig. 3.48). The majority (29) possessed characteristics that were strongly male and were therefore classified as definite males. For five individuals (skeletons 3700, 3783, 3796, 3798, 3799) the classification was less certain owing to the fact that their pelves, the most reliable region of the skeleton for estimating sex (Cox 2000), were either missing, too damaged, or were not fully developed (ie were unfused). Instead, estimations relied on measurements of vertical diameters of articular surfaces which are less reliable, because of considerable variation between populations and individuals (Schwartz 1995). For the present cases, measurements of the glenoid fossa (skeleton 3700), femoral head (skeletons 3796, 3798) and radial head (skeletons 3799, 3783) were employed with reference to the data by Stewart (1979).

All but five discrete skeletons could be assigned an age range and, of these, 45% were adolescents or young adults (18–25 years) and 37.5% were prime (26–35 years) or mature (36–45 years) adults. Only three individuals estimated to have been over 45+ years (Table 3.25, Fig. 3.48).

Three skeletons could only be assigned across two age categories. These were 3794, recorded as a young/prime adult (20–30 years) and two prime/mature adults, one (skeleton 3715) 30–40 years and

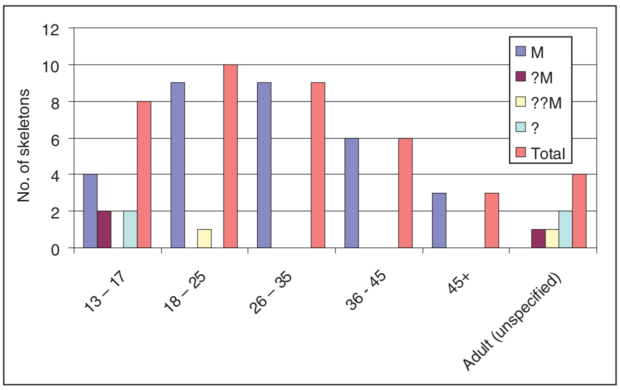


Fig. 3.48 Mortality profile of discrete infra-cranial skeletons (N=40)

Table 3.25 Distribution of age and sex: infra-cranial skeletons

	M	*?M*	*??M*	*?*	*Total (%)*
13 - <18	4	2		2	8 (20.0)
18 – 25	9		1		10 (25.0)
26 – 35	9				9 (22.5)
36 - 45	6				6 (15.0)
45+	3				3 (7.5)
Adult (unspecified)		1	1	2	4 (10.0)
Total (%)	31 (77.5)	3 (7.5)	2 (5.0)	4 (10.0)	40

one (skeleton 3762) 25–44 years. For the purposes of analysis, they have been assigned to the age categories prime adult (skeletons 3794 and 3715) and mature adult (skeleton 3762), but this does not greatly alter the mortality profile. This was undertaken by giving greater weight to pubic symphysis age over auricular surface age. This is because the pubic symphyses in this group consistently suggested a younger age than auricular surfaces, even among skeletons where other indicators, namely, epiphyseal fusion, supported a younger age.

Of the three 45+ year olds, two (skeletons 3687 and 3804) were estimated to have been over 50 years of age and one (skeleton 3805 (3807,3808)), between 40 and 60 years of age. The youngest individuals (eight adolescents) were assigned age ranges that included a minimum of 11 years and a maximum of 18 years. Most were in their early or mid teens. All of the individuals who could not be assigned to an age range were judged to have been over 18 years old and were assigned to the category 'adult unspecified'.

Stature

Potential adult stature is largely governed by genetics, although environmental factors experienced during the growth period, notably nutritional status and disease, can influence the actual height achieved by an individual (Larsen 1997, 13-19). For this reason, stature may be used as a rough indicator of physiological stress encountered by a population (Roberts and Cox 2003, 195).

Stature was calculated for all complete and partial skeletons with a measurable femur (22 individuals) (Fig. 3.49). The estimated average stature was 172.1cm (SD 5.27cm), approximately five feet, eight inches. The range was 162.6cm (*c* 5 feet 3 inches) to 184.0cm (*c* 6 feet). Most of the individuals (nine) were between 166 and 170cm tall. A further five were between 171 and 175cm tall, another five, 176–180cm and one was between 181–190cm. This is a fairly mixed distribution of heights.

Compared with other assemblages (Table 3.26), these results are in keeping with other contemporary populations from both Britain and northern Europe. They are also in keeping with the figures reported by Roberts and Cox (2003, 195) for a range of early medieval (AD 410–1050) British sites (mean 172cm, range 170–182cm), which reflect an overall increase in height from the Roman period, and is also higher than that calculated for the later medieval period. These trends suggest that nutri-

Table 3.26 Stature comparisons between Ridgeway Hill and broadly contemporary sites (males only)

	Mean stature (cm)	*No. individuals*	*Range (cm)*	*Reference*
Ridgeway Hill mass grave, Weymouth	172.1	22	162.6 – 184.0	
St Helen's, Fishergate, York	170.1	48	156.3 – 186.6	Holst 2005
St Andrew, Fishergate, York, Period 6	171	162	155 – 190 (Period 4 & 6)	Stroud 1993b, 174
St Andrew, Fishergate, York, Period 4	172	43	155 – 190 (Period 4 & 6)	Stroud 1993b, 174
St Peter's, Barton-upon-Humber, North Lincolnshire (Phase E)	169	/	154 – 183	Waldron 2007, 41
Towton, North Yorkshire	171.6	37	158.7 – 183.5	Boylston *et al.* 2000, 54
Castledyke South, Barton-upon-Humber, North Lincolnshire	172	24	160 – 189	Boylston *et al.* 1998, 226
Wally Corner, Berinsfield, Oxfordshire	173	24	/	Boyle *et al.* 1995, 107
Great Chesterford, Essex	166	28	151 – 183	Waldron 1994, 53
Butler's Field, Lechlade, Gloucestershire	170	42	159 – 185	Harman 1998, 44
Cassington, Oxfordshire	169.2	19	163 – 179	after Harman *et al.* 1981, 170-173
Queensford Mill, Oxfordshire	169.8	19	158 – 182	after Harman *et al.* 198, 175-178
Radley, Oxfordshire	170.3	12	161 – 181	after Harman *et al.* 1981, 179-181
Viking Denmark (compilation of Danish sites)	172.6	18	162.9 – 184.8	Sellevold *et al.* 1984, 180, 226
Haithabu (Schleswig)	170.4	13	/	Schaefer 1963, cited in Sellevold *et al.* 1984, 226
Tjodhilde South (Greenland)	173	30	/	Balslev Jørgensen n.d., cited in Sellevold *et al.* 1984, 226
Iceland heathen	173	24	/	Steffensen 1943, cited in Sellevold *et al*. 1984, 226
Skeljastaðir (Iceland)	174	42	/	Steffensen 1943, cited in Sellevold *et al.* 1984, 226
Viking Norway	174	27	/	Schreiner 1927, cited in Sellevold *et al.* 1984, 226

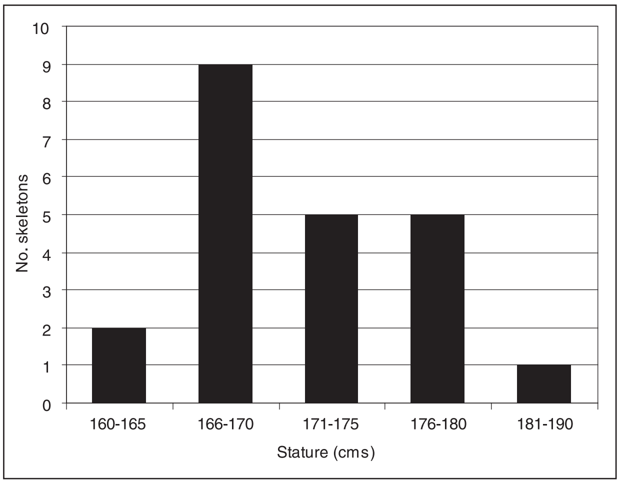


Fig. 3.49 Stature distribution (22 discrete infra-cranial skeletons)

tion was adequate or, that people were efficient at adapting to stress (ibid., 195). However, it is worth considering that the height increase may indicate incomers to the population, that is, 'taller' people from the continent (ibid., 195). Certainly the highest mean statures presented here are from Iceland, Norway and Greenland (after Sellevold *et al.* 1984, 226). It is interesting to note that the Ridgeway Hill mean stature and range are remarkably similar to those for Viking Age Denmark.

Robusticity

According to Wolff's law (1892), bone responds proportionally to functional pressure by increasing or decreasing its mass. This means that repeated strenuous activity will have a physical effect on the skeletal elements involved. In particular, bone at the sites of attachment for muscles, tendons and ligaments will respond to the forces exerted upon them, resulting in larger, more robust dimensions (Knüsel 2000b, 104). When considering robusticity in a skeletal population it is important to consider the different ways in which juvenile and adult skeletons respond to repeated, strenuous activity. In juveniles, the joints are more readily affected, that is changes in joint sizes relate to activity of early life, whereas the shafts of long bones bear the effect of activity in adulthood (ibid., 104; Knüsel 2000a, 384-5). In addition, it is also important to consider that other factors besides habitual activity, such as physique and climate, can also affect skeletal robusticity (Stock 2006).

Robusticity was explored in the Ridgeway Hill skeletons by metrical assessment applied to the calculation of indices, and by visual assessment of muscle attachment sites.

Indices

Calculation of robusticity indices, which use the ratio of a bone's diameter to its length, can give an indication of an individual's build, or 'heftiness' (Knüsel 2000b, 104). Several upper and lower limb robusticity indices were calculated for the Ridgeway Hill individuals (complete and partial skeletons only) and are detailed in Table 3.27. Although comparative data for the Ridgeway Hill robusticity indices was limited, a small number of suitable datasets were available. For the purposes of comparison, indices of the upper limbs were calculated using the bones of the right side of the body. For the lower limbs, preference was given to the left side of the body, but right sides were included for individuals with no left side available in order to increase the sample size.

The claviculo-humeral index is an indicator of upper body physique. At 43.4, the mean for the Ridgeway Hill individuals is in keeping with the mass grave assemblage from Towton (42.94, N= 16) and the Gilbertine Priory assemblage (Period 6) from St Andrew's, Fishergate (44.13, N=29, cited in Knüsel 2000b, 104).

The mean femoral robusticity of the Ridgeway Hill group (excluding isolated limbs/extremities), although slightly lower than, was in keeping with that of Towton (12.87, N=32) and St Andrew's, Fishergate's Gilbertine Priory assemblage (13.22, N=55, cited in Knüsel 2000b, 104).

It is unfortunate that a wider range of comparative data for robusticity could not be gathered, given that, for the claviculo-humeral index and femoral robusticity, the two comparative assemblages used are somewhat 'specialised' groups, that is, a potentially higher status Gilbertine Priory population (Stroud 1993a, 255) and an assemblage of fighting-age males who died during battle (Fiorato *et al.* 2000). However, perhaps it is significant that the Ridgeway Hill assemblage compares well with these groups.

The platymeric and platycnemic indices, which are indicators of proximal femur and tibia shaft shape respectively, were also calculated for the Ridgeway Hill group. In the femur, antero-posterior flattening of the shaft is assessed. The index of the femur has increased over time, that is, the femur has become more rounded, and there are various hypotheses as to the reason for this, including mechanical stress, squatting and mineral/vitamin deficiencies (Brothwell 1981, 90-91; Waldron 2007, 46). In the tibia, the transverse flattening is assessed. Again, there are various hypotheses concerning the reason for tibial flattening, which include pathological change, muscular action and persistent squatting (Brothwell 1981, 91; Waldron 2007, 46).

The mean platymeric index for the Ridgeway Hill group (excluding isolated limbs/extremities) was

Table 3.27 Robusticity indices

Index	*Mean*	*Range*	*No. of individuals*
Humeral robusticity	19.64	18.26 – 21.7	13
Claviculo-humeral index	43.4	39.62 – 45.82	5
Radio-humeral index	77.08	73.71 – 79.25	10
Femoral robusticity	12.3	11.13 – 13.57	21
Platymeric index	80.35	69.44 – 91.89	31
Platycnemic index	73.94	61.76 – 93.33	25

80.35, which falls into the category of platymeria (index below 84.9, Brothwell 1981, 89), indicating a flat or broad proximal femur shaft. Of the 31 individuals for which the platymeric index was calculated, 80.6% (25/31) were platymeric and 19.4% (6/31) were eurymeric. Platymeric femurs were also most commonly observed in other broadly contemporary male assemblages, including Heronbridge, Great Chesterford, St Peter's, Barton-upon-Humber and St Helen's, Fishergate.

At 73.94, the platycnemic index is eurycnemic (index over 69.9). A total of 17 individuals (68%, 17/25) had eurycnemic indices, seven (28%, 7/25) had mesocnemic indices, whilst only one individual (4%, 1/25) exhibited platycnemia. This is also in keeping with the contemporary populations at St Peter's, Barton-upon-Humber and St Helen's, Fishergate. At Great Chesterford however, the tibia were more commonly flattened, with most calculated indices falling within the mesocnemic range.

Muscle, tendon and ligament attachment sites

Other evidence for physical robusticity may be explored by the analysis of individual muscle attachment sites on bones. For the Ridgeway Hill individuals, a total of 39 muscle, tendon and ligament attachment sites were systematically examined, visually, in each skeleton. In accordance with Hawkey (1998), observable attachment sites were assigned one of four possible robusticity scores: 0 (no marking seen), 1 (faint changes), 2 (moderate changes) or 3 (strong changes). Only those individuals exhibiting attachment sites assigned a score of 3 (including those scored as 2-3) are discussed here.

A total of 12 individuals (excluding isolated limbs/extremities) exhibited strong changes at attachment sites. These are summarised in Table 3.28.

Niinimaki (2011, 297) found that there was a positive relationship between musculoskeletal stress markers (MSMs) and increasing age, and this was certainly reflected in the Ridgeway Hill assemblage. Of the ten mature or older adult skeletons that had observable attachment sites, five of them (50%) were assigned a score of 3 for at least one attachment site. It is not known whether the relationship reflects the cumulative amount of repetitions that an older individual has done, or whether older bone tends to develop more surface area to strengthen bone-muscle attachment against decreasing bone density (ibid., 297). The presence of marked robusticity scores in the adolescent and young adult age categories are a good indication that these individuals were experiencing repetitive, and probably heavy, mechanical stresses from a young age.

In the upper body, there was no clear pattern to the attachment sites affected, but those of the clavicle and humerus were most frequently involved. The costo-clavicular ligament attachment sites were marked in three individuals, and in all cases this was bilateral. In the humerus, strong robusticity scores were noted at *pectoralis*

Table 3.28 Individuals exhibiting Score 3 at attachment sites

Skeleton No.	*Age category*	*Upper/lower body affected*	*Attachment site/s with robusticity score 3*
3715	Prime adult	Lower	L & R femur – *gluteus maximus*
3754	Adolescent	Upper	L & R Clavicle – deltoid
3756	Adolescent	Upper	R ulna – supinator (L = NR)
3762	Mature adult	Upper	R ulna – *brachialis* (L = NR)
3764	Prime adult	Lower	L & R tibia – *soleus*
3799	Adult (unspec.)	Upper	R humerus – *pectoralis major* (L = NR); L radius – *biceps brachii* (R = 2)
3800	Mature adult	Upper & lower	L & R clavicle – costo-clavicular ligament; L & R humerus – *pectoralis major*, deltoid; R humerus – *teres major* (L = 2); L & R femur – *gluteus maximus*, *linea aspera*
3803	Mature adult	Upper	L & R humerus – deltoid
3806	Mature adult	Upper & lower	L & R costo-clavicular ligament; L & R humerus – extensors; L & R femur – *gluteus maximus*
3810	Young adult	Upper & lower	L & R costo-clavicular ligament; L femur – *gluteus maximus* (R = 2)
3783	Adult (unspec.)	Upper	L & R clavicle – conoid ligament, *trapezius*
3805	Older adult	Lower	R femur – *gluteus maximus* (L = 2)

major and deltoid attachment sites in two individuals. Where both left and right sides were observable, these too were bilateral. All of these attachment sites are involved in the motion of the shoulder joints and arms.

Of the lower body attachment sites affected, the attachment for *gluteus maximus* was the most frequently affected. This muscle is predominantly responsible for extension and lateral rotation of the hip.

Upper limb asymmetry and handedness

The bones and joints of the upper limbs are most likely to reveal information about activity because, beyond the stages of crawling (within the first two years of life), they are used almost exclusively in voluntary activities, that is, manipulation of objects and tools (Knüsel 2000b, 104). Most individuals have a dominant arm, which they will use preferentially in such activities. As a result, the bones of the upper limbs may exhibit asymmetry in terms of bone mass/robusticity (ibid., 105).

Table 3.29 shows the mean and ranges of a suite of humeral measurements taken for the Ridgeway Hill assemblage. In addition, the number of individuals with a dominance to one side or the other, is given. It should be noted that all cases of metrical asymmetry observed were slight. The vast majority of differences were 1–2mm, with the maximum difference in any one case just 3mm. That said, some interesting patterns were noted. The maximum breadth of the greater tubercle had more individuals exhibiting a right-side dominance. This mirrors the Towton assemblage, where a clear right-side dominance was observed (Knüsel 2000). However, in contrast to Towton, the maximum transverse head diameter showed no clear side dominance. In the Towton males there was a clear right-side dominance in this measurement too. In both the Ridgeway Hill and Towton groups there was no clear side dominance of the minimum circumference of the humeral shaft. Interestingly, in the Ridgeway Hill group there was a left-side dominance for both measurements involving the elbow region (epicondylar breadth and distal articular breadth). Similarly, at Towton more individuals had a left-side dominance in these measurements than in the other three, particularly for the distal articular breadth, where 10 of 14 individuals showed left-side dominance. Since, as stated above, articular changes occur in youth, this may suggest that the individuals involved had been using their left arms in a strenuous fashion from an early age, prior to physiological maturity (Knüsel 2000b, 107).

In addition to humeral measurements, handedness was also explored with reference to asymmetry

Table 3.29 Asymmetry in humeral measurements (in mm)

	Mean	*Range*	*No. of individuals*	*No. of individuals with dominance to side (no. of individuals with L & R sides available for measurement)*
Humerus transverse head diameter				
L	48.27	46 – 51	15	4 (11)
R	48	44 – 52	13	4 (11)
Humerus Max breadth greater tubercle				
L	35.62	28 – 39	13	2 (9)
R	34.36	29 – 38	11	4 (9)
Humerus Min shaft circumference				
L	66.57	61 – 79	21	5 (19)
R	66.54	61 – 80	24	5 (19)
Humerus epicondylar breadth				
L	64.74	59 – 71	19	4 (15)
R	65.27	60 – 70	22	3 (15)
Humerus distal articular breadth				
L	46.58	42 – 50	19	7 (15)
R	47.13	42 – 52	23	2 (15)

in the level of robusticity at muscle, tendon and ligament attachment sites, as described above. This was in addition to assessment of glenoid bevelling and posterior deflection of the glenoid cavity in the scapula, comparison of left and right clavicle lengths, and of combined humerus, radius and ulna lengths, after Byers (2005).

Assessment of handedness using these methods was carried out on a total of 18 individuals. In the vast majority of cases the results were inconclusive, either because too few traits were recordable to provide a reliable estimate of handedness, or because the traits observed exhibited a mixture of results. Five individuals (3753, 3762, 3777, 3787 and 3810) exhibited possible preferential use of the right upper limb, whilst only one individual (3778) exhibited a left-side dominance. Of the observable left and right humeral measurements in skeleton 3778 only one, the minimum shaft circumference, showed a slight side dominance, and this was to the left side.

Non-metric traits

Non-metric traits are defined above in the section that reports on the skulls (p.59). In the post-cranial skeleton, they include localised deficiencies of bone (for example, as extra blood vessel openings or foramen) and variations in joint facet morphology (for example, the splitting of a typically single joint facet into two separate ones). Traits which involve variations in joint surfaces tend to be more environmentally influenced, a reflection of mechanical factors operating on the bones (Mays 1998, 110). This is in contrast to some cranial traits (for example, variations in the sutures of the skull), which have been proven to be under significant genetic control (Torgersen 1951a & b; 1954; Sjøvold 1984; 1987).

For each post-cranial skeleton, a total of 31 non-metric traits (Finnegan 1978) were scored as present, absent or unobservable. Table 3.30 shows the non-metric traits that were scored and the frequency of each trait within the assemblage. Not included in the table are non-metric traits involving the atlas bone (four in total). Not surprisingly, given the nature of the assemblage, only one skeleton had an atlas that could be assessed for the presence of double facets or bipartite transverse foramen. Neither of these traits was present (the atlas was not observable for the other non-metric traits, lateral and posterior bridging).

By far the most frequently observed traits were the calcaneal double anterior facet, the hypotrochanteric fossa in the femur, and the tibial lateral squatting facet. The talar articular surfaces of the calcaneus are known to display marked variations (Anderson 1987, 15) and in the Ridgeway Hill group a double anterior calcaneal facet was observed in 34.5% of right and 51.6% of calcanei, making this the most frequently observed non-metric trait. The causes of this trait are not clear, but it is noted to be more common than the absence of an anterior facet (ibid., 15) as was the case in the Ridgeway Hill group. This trait was also amongst the most commonly observed in the Anglo-Saxon skeletons from Great Chesterford, Essex (Waldron 1994, 54) and in the Period 4 and Period 6 males from St Andrew's, Fishergate.

The hypotrochanteric fossa was the second most frequent trait, observed in 48.4% of right femora and 45.2% of left femora. This trait manifests as a vertical groove in the superior posterior part of the femoral diaphysis, between the gluteal ridge and the lateral margin (Finnegan 1978, 24). Anderson (1987, 12) notes that its manifestation is not directly linked to bone robusticity or muscularity, but that there may be a slight correlation between the presence of this trait, and platymeria. At Great Chesterford, Essex, the hypotrochanteric fossa was the fourth most frequently observed trait (of 12

Table 3.30 Frequency of post-cranial non-metrical traits

Trait	*Midline*	*R*	*L*
Supra-scapular foramen		0/1 (0.0%)	0/7 (0.0%)
Scap – acromial artic. facet		0/15 (0.0%)	1/14 (7.1%)
Sternal foramen		1/10 (10.0%)	
Humerus – septal aperture		0/33 (0.0%)	0/24 (0.0%)
Humerus – supra-condyloid process		2/33 (6.1%)	1/24 (4.2%)
Pelvis/sacrum – access. Sacral facets		2/13 (15.4%)	2/10 (20.0%)
Pelvis/sacrum – Lumbarisation	1/30 (3.3%)		
Pelvis/sacrum – Sacralisation	1/30 (3.3%)		
Acetabular crease		3/23 (13.0%)	2/22 (9.1%)
Fem – Allan's fossa		2/28 (7.1%)	3/28 (10.7%)
Fem – Poirier's facet		2/26 (7.7%)	1/26 (3.8%)
Fem – plaque formation		1/26 (3.8%)	2/26 (7.7%)
Fem – 3rd trochanter		5/29 (17.2%)	8/30 (26.7%)
Fem – hypotrochanteric fossa		15/31 (48.4%)	14/31 (45.2%)
Fem – exostosis in trochanteric fossa		2/26 (7.7%)	3/27 (11.1%)
Patella – emarginate		0/26 (0.0%)	0/26 (0.0%)
Patella – vastus notch		3/27 (11.1%)	3/26 (11.5%)
Patella – vastus fossa		1/28 (3.6%)	0/26 (0.0%)
Tib – medial squatting facet		0/26 (0.0%)	1/27 (3.7%)
Tib – lateral squatting facet		11/23 (47.8%)	11/26 (42.3%)
Talus – os trigonum		1/24 (4.2%)	1/27 (3.7%)
Talus – double inf facet		4/24 (16.7%)	6/31 (19.4%)
Talus – lat. talar extension		5/26 (19.2%)	6/31 (19.4%)
Talus – medial talar facet		3/26 (11.5%)	2/31 (6.45%)
Calcaneus – ant facet absent		1/29 (3.4%)	1/31 (3.2%)
Calcaneus – double ant facet		10/29 (34.5%)	16/31 (51.6%)
Calcaneus – peroneal tubercle		6/23 (26.1%)	1/23 (4.3%)

post-cranial traits scored), although the rate was lower (26%) than that of the Ridgeway Hill group.

Extension of the inferior articular surface of the tibia onto the antero-medial or antero-lateral surface is known as a medial or lateral squatting facet (respectively). As the name suggests, these facets are thought to result from pressure from the opposing surface of the talus during dorsiflexion, which occurs in squatting postures (Capasso *et al.* 1999, 112). Facets of this type have also been associated with habitual flexion of the foot during standing and climbing ladders, particularly when carrying heavy loads, and also from the stresses of habitual kneeling (ibid., 112). This said, Anderson (1987, 15) points out that a hereditary interpretation should not be ruled out. Others have also questioned the link with activity (Waldron 2007, 51).

Lateral squatting facets were the third most frequently observed non-metric trait in the Ridgeway Hill group, having been observed on 47.8% of right and 42.3% of left tibiae. Medial squatting facets were far less frequent. The higher frequency of lateral squatting facets has been noted in numerous other studies (Anderson 1987, 15), including St Andrew's, Fishergate, where the Period 4 males exhibited frequencies of 63.3% (right) and 68 % (left) for lateral squatting facets, compared with 3.2% (right) and 0% (left) for medial facets.

Evidence for shifting of the lumbosacral border was observed on complete skeletons 3763 and 3805. In the former, the border had shifted in a caudal direction (lumbarisation), meaning that the first sacral vertebra was separate from the rest of the sacrum and had assumed the form of the last lumbar vertebra. Bifurcation of the first sacral neural arch was also noted. In the latter, the lumbar vertebra had assumed the form of the first sacral vertebra, with the lumbosacral border having shifted in a cranial direction (sacralisation). Neither of these abnormalities would have caused symptoms in life (Aufderheide and Rodríguez-Martín 1998).

Another non-metric trait observed in the assemblage, although not formally scored, was *calcaneus secondarius*, a small ossicle located at the antero-medial angle of the dorsal calcaneal surface. In skeletal material, a small notch is visible in this region of the calcaneus (Anderson 1987, 16). There are approximately 30 tarsal accessory bones (including *os trigonum*), and *calcaneus secondarius* is one of the less common types (ibid., 16). These accessory bones appear as separate cartilaginous elements in foetal life (Klenerman 1982, 361, cited in Anderson 1987, 16), suggesting a high genetic component, but developmental influences are responsible for its persistence into adulthood (Anderson 1987, 16).

In skeletons 3755 and 3775, bilateral *calcaneus secondarius* was observed, and in skeleton 3794 it was observed in the right bone, but not the left. A further possible case was seen in the right calcaneus of skeleton 3754, but in this instance, the notch was larger than normally observed, thus an antemortem ununited fracture of the anterior margin could not be ruled out. Given that this trait is comparatively rare, and may be influenced by genetics, it is interesting that three, possibly four, cases were observed in the Ridgeway Hill group. *Os trigonum*, a small ossicle located at the tip of the postero-lateral talar process, was observed in only two skeletons (unilateral in both cases).

A further non-metric trait that was not formally recorded for the group, but was observed in one individual (skeleton 3775) was a double, distal articular facet, on the medial cuneiform. This trait is also thought to be rare and, as with *calcaneus secondarius*, is thought to be highly genetically influenced (Anderson 1987, 18). In addition, symphalangism was observed in four individuals and involved three right, one left and two foot phalanges of unknown side. This is a rare abnormality in which there is fusion between the interphalangeal joints of the fingers and toes. The condition can cause stiffness and impaired function (gripping and pinching) and is usually accompanied by outwardly visible deformity in the affected finger or toe.

Ante-mortem pathology and trauma

Congenital and developmental abnormalities

This refers to abnormalities in growth or development, which vary considerably in their prevalence in both modern and archaeological populations. They may be caused by factors such as malnutrition during the development of the foetus, or they may be genetic in origin. In life, they may not become evident until the period of growth or young adulthood, or they may be present at the fetal stage, or at birth. The most common abnormalities are relatively minor and involve the spinal column (Barnes 1994).

A total of 12 individuals (seven complete skeletons and five partial skeletons) from the Ridgeway Hill assemblage had one or more abnormalities involving the axial and/or appendicular skeleton (Table 3.31).

Spondylolisis

One individual, 3794, had spondylolisis, a defect in which there is separation in a vertebral arch between the body and the spinous process (Merbs 1996). In the present case, the condition involved the fifth lumbar vertebra, the most common part of the spine to be involved (ibid., 201). The cause is

Table 3.31 Summary of congenital and developmental abnormalities

Skeleton No.	*Context type*	*Age*	*Os acromiale*	*Super-numerary ribs*	*Spon-dyl-isis*	*Abnormal styloid*	*Miscell-aneous*	*Details*
3689	P	Prime adult		1				Supernumerary rib (R, cervical)
3715	P	Prime adult					1	Probable developmental asymmetry in sizes of CV/TV spine articular facets, crease defects on TV1, CV3 & 4 artic facets & abnormal rib curvature – ?scoliosis
3763	C	Young adult				1		Developmental absence of R MC3 styloid, reduced styloid in L MC3
3764	P	Prime adult					1	Developmental anomaly on fibula joint surfaces of L & R talus & posterior calcaneus (achilles region)
3775	C	Adolescent	1					Bilateral *os acromiale* (& possible bipartite/tripartite os)
3787	C	Young adult				1		Developmentally flattened ulna styloids (bilateral);
3788	P	Adult unspec	1				1	Bilateral *os acromiale;* Undiagnosed – abnormal morphology of L ribs 1&2 –?activity related, ?developmental anomaly, ?fractured
3794	C	Prime adult	1		1			Bilateral *os acromiale*; Spondylolysis (LV5)
3799	P	Adult unspec				1		Developmentally absent MC3 styloid (L, unilateral)
3803	C	Mature adult	1				1	*Os acromiale* (R side, L not observable); Undiagnosed – asymmetry in the size & angle of LV1 inferior processes – ?trauma, ?developmental anomaly
3805	C	Older adult	1					Unilateral *os acromiale* (L side)
3806	C	Mature adult	1				1	Possible *os acromiale* (may not belong to this individual); Undiagnosed – lesion at sup aspect of R acetabulum
Total			6	1	1	3	5	

(C=complete skeleton; P=partial skeleton)

unclear, but an underlying congenital weakness in the bone, combined with repetitive stress is generally favoured (Waldron 1993, 180). In modern clinical practice, the condition is commonly seen among adolescents who participate in high impact sports and adults who engage in physically demanding occupations (Jurmain 1999). It is under-reported in archaeological populations which reflect a prevalence of anything between 1% and 12% (Knüsel and Fibiger 2005). A total of 30 fifth lumbar vertebrae could be observed for the condition from Ridgeway Hill and therefore this gives a prevalence of 3.33%.

Os acromiale

Six individuals (15%; 6/40) had abnormally developed scapulae, suggestive of considerable stress on their rotator cuff muscles during adolescent growth and development. In this condition, known as *os acromiale*, the acromion process fails to fuse to the spine of the scapula; this would otherwise occur between 18 and 20 years (Scheuer and Black 2000). Archaeologically, the condition has been observed in higher frequencies among sailors from the Mary Rose Tudor warship and soldiers from the Battle of Towton, AD 1461, than in the general population (Knüsel 2000b, 115). This trend may refer to the early commencement of activity affecting the shoulder region among specialised groups (Knüsel 2000b, 116).

Of the six cases seen in the present assemblage, three were bilateral (skeletons 3775, 3788, 3794) and one (3805) was unilateral (left side). In a further case (3806) a left scapula was involved, but not the right, although there was some uncertainty as to whether this bone belongs with the rest of the skeleton (this case has been included in all statistics). A final case (3803) had *os acromiale* involving the right side, but the left side could not be observed in order to determine whether it was present or not.

Considering the overall true prevalence, 13.85% (9/65) of all scapulae were affected, with more left sides (15.63%, 5/32) involved than right sides (12.12%, 4/33). This exceeds the true prevalence calculated for the Towton soldiers (8.6%) and the sailors from the Mary Rose (10.6%). Like Ridgeway Hill, a tendency towards a higher prevalence on the left side (6.9% right and 10.3% left) was also seen among the Towton individuals (Knüsel 2000b, 115).

Other abnormalities

Some abnormalities seen in the assemblage were less frequent and are generally less common in archaeological material. One individual (skeleton 3689) had a supernumerary rib, in this case a cervical right rib. In two individuals the right (skeleton 3763) and left (skeleton 3799) third metacarpal styloid processes were absent. In one of them – skeleton 3763 – the other side was present but was reduced in size, and in the other – skeleton 3799 – the other side had a normal morphological appearance. Lastly, a well defined facet was observed on the joint surface for the fibula on the right and left talus bones of skeleton 3764. The margins were regular and smooth indicating that this is likely to be developmental.

Other abnormalities were diagnosed as congenital/developmental with less certainty. Among these was skeleton 3787 which had an abnormally flattened ulna styloid processes. This may have been traumatic in origin, but a developmental classification is preferred because of the lack of overall deformity, coupled with the fact that the abnormality was bilateral.

Asymmetry was observed in the size and angle of the first lumbar vertebra inferior articular processes of skeleton 3803. Similarly, the superior and inferior articular facets of the cervical and thoracic vertebrae of skeleton 3715 were asymmetrical in their size and several right and left ribs displayed abnormal curvature, having a twisted appearance. These changes suggested that the individual had a scoliotic spine, although fragmentation precluded reconstruction of the vertebral column to confirm this. There were no other lesions, including those of a lytic or blastic nature, and therefore the preferred diagnosis is possible congenital scoliosis.

Lastly, the second left rib of skeleton 3788 had an elongated neck region which also appeared twisted. The neck of another left rib, from the same individual, was also thinned and elongated. Despite these changes the ribs were otherwise 'normal' in their appearance, with smooth, biological margins. Apart from some degenerative changes in the spine and possible ante-mortem trauma involving the scapulae, no other ante-mortem lesions were observed on the skeleton. It is therefore tentatively suggested that the deformed ribs were developmental in origin.

Metabolic conditions

These are triggered by an excess or a deficiency in the body's dietary requirements and hormones and result in specific changes to the skeleton, such as in the form of increased or decreased bone turnover. They include *cribra orbitalia* (iron deficiency anaemia), scurvy and rickets (to name but a few).

Very limited evidence for metabolic disease was observed on the skeletons, although it should be noted that most cases seen archaeologically are diagnosed from changes on the skull (for example, *cribra orbitalia* and to an extent scurvy). A total of 11 skeletons, complete and partials (27.5%, 11/40), had *cribra femoralis*, which refers to a defect on the anterior femoral neck, just inferior to the head. Morphologically identical to *cribra orbitalia*, the defect was identified as thinning of the cortical bone and increased porosity (Djuric *et al.* 2008). It was distinguished from Allen's fossa (see above), which may be present in the same location, but has been identified as a clear, circumscribed defect with exposed trabeculae and smooth margins, considered to be a non-metric trait. To date, *cribra femoralis* has received most attention in work on European populations, where it has been discussed in association with *cribra orbitalia* and *cribra humerus* (the same morphological changes, but this time on the neck of the humerus) (for example, Djuric *et al.* 2008). The aetiology is far from understood, but normal growth related changes, iron deficiency anaemia, and even magnesium deficiency have all been considered (Djuric *et al.* 2008).

Cribra femoralis was observed on 27.3% (9/33) of all right and 33.3% (10/30) of all left femurs of complete and partial skeletons, or 25.7% (9/35) of all right and 31.3% (10/32) of all left femurs of all femurs from complete, partial and extremities. In eight individuals the condition was bilateral, in two only the left side had the condition without involvement of the right side, and in one the right side was involved with the left unaffected.

Infection

Infection manifests on bone in the form of inflammation and may involve the marrow cavity ('osteomyelitis'); the cortical bone ('osteitis'); or the fibrous sheath that covers the bone, the periostium ('periostitis'). These changes may be observed as a result of tuberculosis, leprosy, syphilis (among others) or, where the pattern of change is non-diagnostic and the pathogen is unknown, non-specific infection. Infection may arise as a result of pathogens spreading from an adjacent lesion via the blood stream (for example, as seen in trauma, chronic skin ulceration, paranasal sinsistis, middle ear cavity infection, a dental abscess and visceral rib surface inflammation), or as a result of direct implantation into bone (for example, as seen in puncture and penetrating injuries).

Periostitis

Periostitis is the most commonly observed lesion in archaeological populations in this category. It may be identified on dry bone as fine pitting, longitudinal striations, swelling and /or plaque like new bone formation on the original bone surface. Such surface inflammation may also affect the cranium, but owing to a difference in anatomy, the term periostitis does not apply here. The changes may occur as a result of infection, or they may accompany other conditions of a metabolic, neoplastic or traumatic nature (Resnick and Niwayama 1995). The level of non-specific infection in a given population is generally regarded as an indicator of adaptation or mal-adaptation to environmental conditions, or more specifically, malnutrition, poor sanitation and generalised health stress (Roberts and Manchester 1995).

A total of 22 complete and partial skeletons and eight isolated limbs/extremities had periosteal lesions. Counting discrete articulated skeletons only (40 individuals), the lesion was seen on 55% (22/40).

Table 3.32 Contexts with non-specific bone inflammation and probable or possible associated trauma

Skeleton No.	*Context type (complete/partial/ limb or extremity skeleton)*	*Element with periostitis*	*Trauma lesion*
3699	L/ex	Dorsal surface of R 1st distal hand phalanx	Possible fracture (alternatively nail infection?)
3774	L/ex	R femur, anterior surface middle/distal portion	R patella trauma muscle tear or ? avulsion fracture
3780	L/ex	L tibia, talus, calcaneus, navicular, all 3 cuneiforms, cuboid and fibula	Healing fracture (distal L tibia)
3784	L/ex	Left tibia and fibula (not in same locations as the trauma involving the same fibula)	Healed fracture and possible muscle trauma/haematoma (could be neoplastic?) L proximal fibula
3792	L/ex	R tibia and L medial cuneiform plantar surface	1st L metatarsal fracture
3795	P	L5, S1	Possible trauma to L5
3799	P	Right rib fragment	Healed fracture
3805	C	L tibia	Possible haematoma
3811	P	Proximal L tibia (lateral aspect)	Proximal R tibia *myositis ossificans* (lateral aspect)

Table 3.33 Discrete articulated skeletons with periostitis: distribution of elements involved by skeleton

Skeleton	*Age category*	*Ribs*	*Right humerus*	*Vertebrae*	*Innominate*	*Right femur*	*Left femur*	*Right tibia*	*Left tibia*	*Right fibula*	*Left fibula*
3688	Adult unspecified	X									
3689	Prime adult	X									
3700	Young adult			X							
3715	Prime adult			X							
3753	Young adult							X	X		
3756	Adolescent					X	X			X	X
3762	Mature adult					X			X		
3763	Young adult					X	X				
3770	Prime adult							X	X		
3799	Adult unspecified	X	X								
3781	Prime adult					X	X	X	X		
3789	Adolescent					X	X	X	X		
3795	Prime adult			X	X				X		X
3800	Mature adult								X		
3801	Prime adult							X			
3803	Mature adult							X			
3804	Older adult			X				X			
3805	Older adult								X		
3806	Mature adult			X		X	X	X	X		
3809	Young adult					X	X				
3805	Older adult								X		
3811	Prime adult							X			

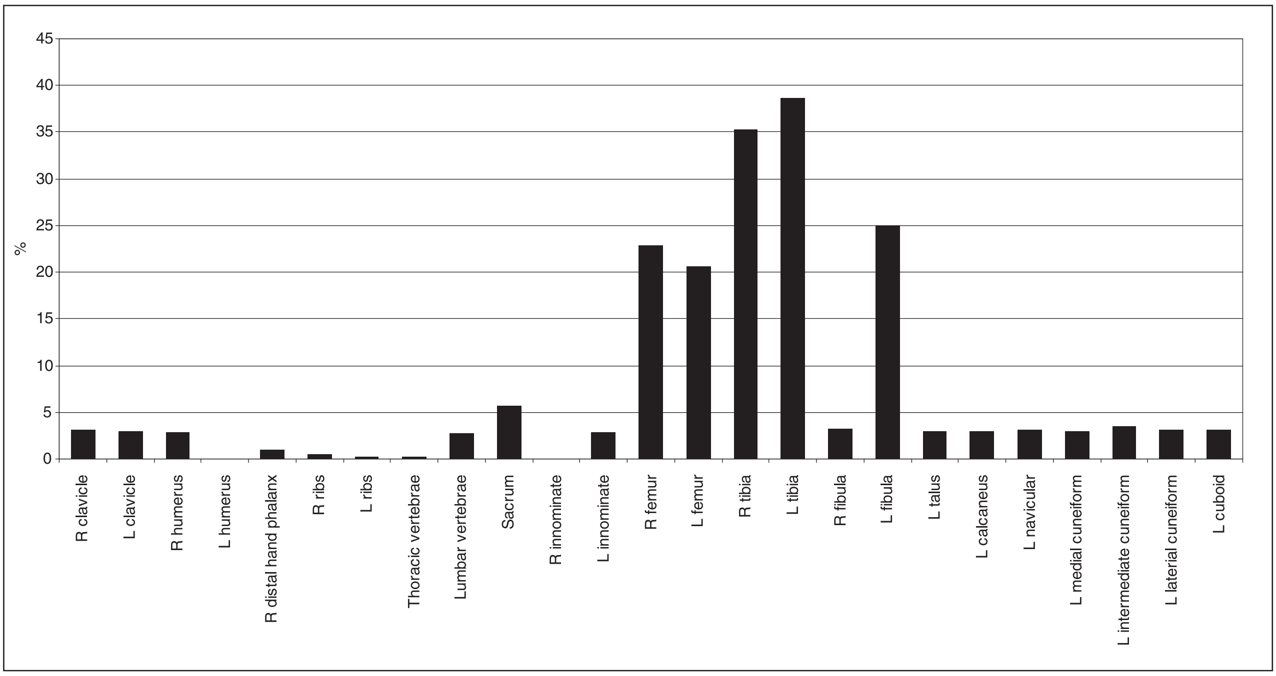


Fig. 3.50 Distribution of periostitis by element (TPR; 40 discrete infra-cranial skeletons)

This rate would seem to be much higher than male CPRs observed among some rural cemetery populations, including St Peter's, Barton-upon-Humber (11.1%) and Wharram Percy (Anglo-Saxon to post-medieval: 9.48%); but lower than male rates observed at the urban site at St Helen's, Fishergate (60%). In nine cases the lesion may have been or was probably secondary to ante-mortem trauma (Table 3.32). This number includes four discrete articulated skeletons and five limbs/extremities.

At the assemblage level periostitis showed wide skeletal involvement with changes seen on elements from the upper and lower limbs and the thorax (Fig. 3.50). The most frequently affected elements were the lower limb bones, in particular the left tibia (right 35.3%; left 38.7%). The tibia was also the most frequently affected bone at St Helen's, Fishergate, where the TPR was virtually double (right: 60%; left: 71%). Periostitis is seen most commonly on the tibia in archaeological material, probably because the morphology of the bone makes it more prone to minor trauma (Roberts and Manchester 1995, 130). However, in the present sample, considering discrete articulated skeletons only, a good proportion of tibiae (5/14 skeletons with affected tibiae; 35.7%) were affected bilaterally. Further, the plotted distribution of element involvement among discrete individuals indicates that at least 11 skeletons (50%; 11/22 skeletons with periostitis) had changes that involved more than one element (Table 3.33), this being a minimum number because the plot does not take into account observations that could not be made owing to preservation. This therefore suggests that something other than just mild trauma was causing periosteal reactions in the present sample. Multiple element involvement is indicative of systemic disease, although the patterns of involvement in the present skeletons are not exclusive to any one particular disease process. For example, the hand and foot involvement, clubbing deformities and 'tree bark' periostitis, all suggestive of hypertrophic pulmonary osteoarthropathy, were not observed.

Three complete/partial skeletons, 3688 (adult, >18 years), 3689 (prime adult) and 3799 (adult, >18 years), had periostitis involving three ribs. On 3688 the lesion was healed and was located on the visceral surface of a fragment of shaft, possibly from the left side. On 3689, active and healed new bone was present on the anterior surface of a right rib (possibly the 11th), in the region of the angle of the shaft. No other ribs from this individual had periostitis, but the anterior surfaces of five fragments from the left side had sieve-like porosity, some with generalised thickening, possibly due to osteitis. Sieve-like porosity was also observed on the superior aspects of both clavicle shafts, which also looked re-modelled with smooth lamellar bone. On skeleton 3799 the reactive bone was healed and was secondary to a fracture (see above) and may have been osteomyelitic (see below).

Several tarsal bones were found with periosteal new bone and were all from one isolated limb/extremity (skeleton 3780) probably secondary to trauma involving the ankle. Also possibly related to trauma was the periostitis seen on one hand phalanx of isolated limb/extremity 3699 (see Table 3.32).

On one partial skeleton (adult 3799) active periostitis was present in and around the olecranon and coronoid fossa of the right humerus. This may represent infection within the joint capsule, which is why it has been considered here. Alternatively, the changes may be traumatic in origin, possibly in relation to *osteochondritis dissecans*, seen on the same joint (see 'circulatory conditions' below), or it may relate to an erosive joint condition, possibly associated with erosive changes observed in the right carpal bones (see 'joint disease' below).

Four skeletons (two complete and two partial) had periostitis involving vertebrae and two (3804 and 3715) of these are discussed under 'specific infection'. Among the other skeletons was 3795 (partial skeleton), which had erosive lesions and reactive new bone on the surfaces of the fifth lumbar and first sacral bodies, in addition to small erosive lesions on their right and possibly (the bone was damaged post-mortem) also the left auricular surfaces of the sacrum. The rest of the spine and ribs from this skeleton were missing, so it was not possible to confirm what the involvement of the thorax was (if any). All of these changes may relate to infection secondary to trauma involving the fifth lumbar vertebra (see 'ante-mortem trauma'). The same skeleton had periostitis involving the left tibia and fibula.

Partial skeleton 3700 (young adult) had a small deposit of active new bone on the arch of the ninth thoracic vertebra, just inferior to the left superior facet. No other vertebrae seemed to be affected, although the inferior facets on the eight thoracic vertebra had not survived.

Osteomyelitis among the articulated skeletons

There were no confirmed cases of osteomyelitis. A possible cloaca was observed on the shaft of the right first metatarsal of complete skeleton 3810 in association with enlargement/thickening of the bone. This may have been secondary to *myositis ossificans traumatica* and a possible fracture involving the first and second metatarsals (see ante-mortem trauma section). In addition, a fragment of right rib from partial skeleton 3799 (adult, unspecified) had a healed fracture which was accompanied by healed reactive bone and smooth margined perforations that extended into the shaft. The perforations possibly represent cloacae relating to healed osteomyelitic infection of the bone secondary to fracture. Radiography is required to confirm the presence or absence of osteomyelitis in both of these cases.

Fig. 3.51 Skeleton 3804, spinal lesions consistent with infection, possibly brucellosis. T10 to L5 shown (left antero-lateral view). Details of L3 inferior view (above) and L4 superior (below)

Specific infection

There were no conclusive examples of tuberculosis, syphilis, or other specific infections, however there were some lesions that had particular characteristics in common with some of these and will therefore be considered here.

The first involved three complete skeletons: older adult 3804, mature adults 3806 and 3715. In all of

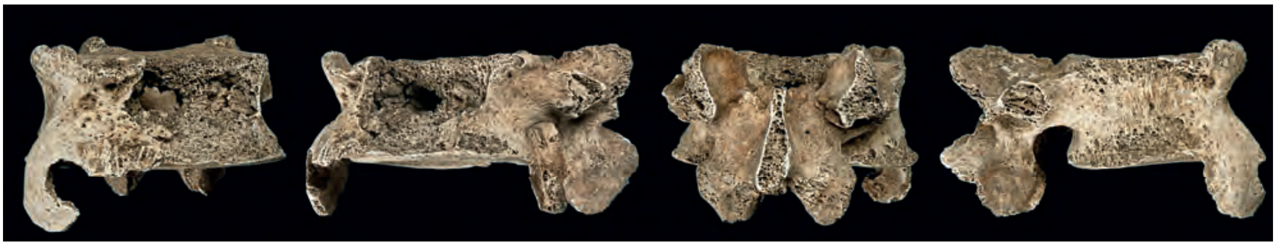


Fig. 3.52 Skeleton 3806, 3rd lumbar vertebra exhibiting 'parrot beak' osteophyte and inflammation, possibly brucellosis

Table 3.34 Description of spines with 'parrot beak' osteophyte and other associated changes

Skeleton No.	*Description*
3804	The third and fourth lumbar vertebrae had large, projecting osteophytes associated with lytic and blastic lesions (Fig. 3.51). When the vertebrae were held in correct anatomical position, the margins of the largest lytic lesions on each vertebra conjoined, forming one large cavity (approximately 10mm in diameter). No other vertebrae were involved and apart from a relatively restricted area of healed periostitis on the right tibia shaft, no other infective lesions were observed on this skeleton.
3806	Large osteophyte with a large cavity (approximately 11-12mm in diameter), roughly in its centre (Fig. 3.52). The vertebra and rest of the spine had suffered bad post-mortem damage and therefore it was not possible to say what other lesions were present, if any. Healed periostitis was observed on both femora and tibiae belonging to this skeleton, but otherwise there were no other ante-mortem lesions that would help to diagnose the changes in the lumbar spine.
3715	Large cavity and inflammation were present on the first sacral vertebra. The cavity was located on the anterior aspect (right side) of the sacrum and was approximately 10-12mm in diameter. As seen in the two previous cases, large, conjoining ostephytes were present on the superior margin of the sacrum and the inferior margin of the fifth lumbar vertebra, and were probably in the process of fusing at the time of death. Lytic lesions were also present on the inferior surface of the fifth lumbar vertebra (Fig. 3.53). A depressed area of bone, approximately 13mm by 6mm in size was present on the left and right acetabulae on the antero-superior aspects, but there was no associated inflammation.

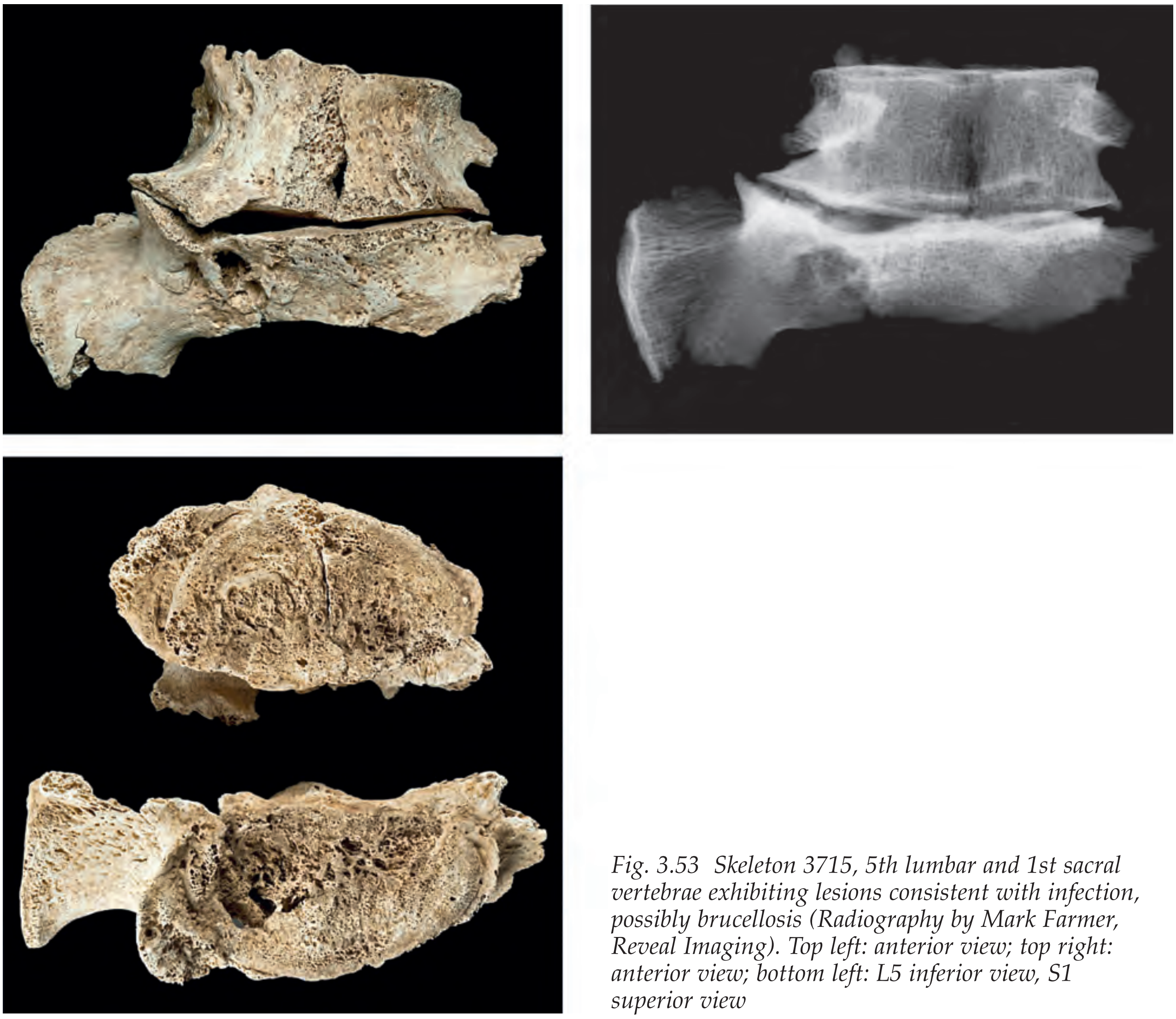


Fig. 3.53 Skeleton 3715, 5th lumbar and 1st sacral vertebrae exhibiting lesions consistent with infection, possibly brucellosis (Radiography by Mark Farmer, Reveal Imaging). Top left: anterior view; top right: anterior view; bottom left: L5 inferior view, S1 superior view

these, large osteophytes, that had a 'parrot beak' appearance, were observed in association with cavitation and, in the case of 3804 and 3806 inflammation (as such these two skeletons have been included in the statistics for periostitis, presented above). Descriptions of the changes are detailed in Table 3.34 and illustrated in Figures 3.51–3.53. Parrot beak osteophyte is consistent with brucellosis. Differential diagnoses include intestinal tuberculosis or infection secondary to trauma (a piercing injury?) to the lower spine.

In addition to these possible cases of brucellosis, one other skeleton (3688) should be considered here because they had changes involving the visceral surfaces of their ribs (discussed above), which may be linked to tuberculosis (Roberts 1999). Rib lesions may be associated with the disease, but are not enough on their own to confirm a diagnosis. The skeleton showed no other changes that could be linked to tuberculosis.

Extra spinal joint disease

Extra-spinal osteoarthritis was diagnosed by the presence of eburnation or at least two of either porosity, osteophyte, and/or bony contour change (Rogers and Waldron 1995). The crude prevalence was relatively low, involving one or more joints of four discrete skeletons only (4/40; 10%). This is not a surprising finding for a group of predominantly young individuals, because the disease is primarily associated with old age. In fact, those skeletons with changes were among the oldest in the group (Table 3.35). The most common joints to be affected in the Ridgeway Hill skeletons were those from the upper body (Table 3.36). This is broadly consistent with the combined TPR for several broadly contemporary British sites where the shoulder (6.4%) followed by the acromio-clavicular joint (5.6%) are the most frequently affected (Roberts and Cox 2003, 198-9). While activity is a recognised factor in the aetiology of osteoarthritis, it may have greater influence over which joints are affected, rather than whether individuals have the disease (Rogers and Waldron 1995). Thus, activities that placed greater stress on upper limb joints, rather than lower limb joints, may have influenced the distribution of the disease in the present sample.

Besides osteoarthritis, other extra-spinal joint diseases seen among the Ridgeway Hill skeletons were limited in number and their extent. Osteophytes around the margins of joints were observed on seven discrete skeletons, including four mature (3762, 3800, 3803 and 3806), one older (3805) and two unspecified (3788 and 3799) adults. In addition, the changes were observed on five limbs/extremities (3698, 3768, 3780, 3784 and 3802). In all, the osteophytes were relatively minor, were unaccompanied by porosity, altered joint contours or eburnation, and probably refer to early stages of degenerative joint changes and/or adaptation. In 3780 and 3802 osteophytosis was observed on the bones of the left feet were probably secondary to fractures involving the distal tibia (3780) and left foot (3802). Joint porosity, also probably a reference to early degenerative change and/or adaptation, was seen on two prime (3764 and 3811), three mature (3762, 3800 and 3806), two older (3804 and

Table 3.35 Skeletons with osteoarthritis

Context No.	*Age*	*Joint(s) affected*
3781	Prime adult	Right acromio-clavicular joint
3799	Adult unspecified	Right elbow
3800	Mature adult	Right and left acromio-clavicular joints
3804	Older adult	Left hip

Table 3.36 Skeletal distribution of extra-spinal osteoarthritis

	No. observed	*No. present*	*%*
R acromio-clavicular	19	2	10.5
L acromio-clavicular	15	1	6.7
R elbow	34	1	2.9
L elbow	27	0	0
R hip	35	1	2.9
L hip	33	0	0

Fig. 3.54 Skeleton 3764, peri-articular lytic lesions on the left and right first metatarsals, possible hallux valgus *(medial views)*

Fig. 3.55 Skeleton 3801, peri-articular lytic lesion on the right first metatarsal, possible hallux valgus *(medial view)*

3805) and one unspecified adult (3799) individuals. This was in addition to one isolated limb/extremity (3768). In all the porosity was relatively minor and was not accompanied by any other joint changes.

Discrete skeletons 3764 and 3801 had peri-articular lytic lesions on the medial aspect of the first metatarsal heads. In 3764 both feet were involved (Fig. 3.54), but on 3801 only the right foot was affected (Fig. 3.55). The lesions had regular, smooth margins and internal surfaces. Erosive changes affecting foot bones may be caused by relatively minor conditions such as *hallux valgus* (bunions), or they may be the result of something more systemic, such as gout. In the present cases the changes were not typical of those seen in gout and *hallux valgus* is the preferred diagnosis.

Conditions of the spine

Schmorl's nodes, osteoarthritis, spondylolisis and osteophytosis were all observed and are common in archaeological and modern populations (Table 3.37).

Table 3.37 True prevalence of conditions of the spine

	Schmorl's nodes	*Osteoarthritis*	*Spondylosis deformans*
CV observed	111	120	111
CV with condition	0	0	7
% CV	0	0	6.3
TV observed	384	365	384
TV with condition	173	45	45
% TV	45.1	12.3	11.7
LV observed	151	165	151
LV with condition	67	1	21
% LV	44.4	0.6	13.9
SV1 observed	35	30	35
SV1 with condition	3	0	2
% SV1	8.6	0	5.7

Table 3.38 Age distribution of infra-cranial skeletons with Schmorl's nodes

	n/N	*%*
Adolescent	5/8	62.5
Young adult	9/10	90.0
Prime adult	7/9	77.8
Mature adult	6/6	100.0
Older adult	3/3	100.0
Adult unspecified	3/4	75.0
Total	33/40	82.5

Schmorl's nodes

Thirty-three discrete skeletons showed evidence for this condition. This gives a CPR of 82.5%, which is similar to Towton where a CPR of over 80% was observed (Coughlan and Holst 2003, 68). This rate far exceeds male rates for non-specialist male populations like Wharram Percy (Anglo-Saxon to post-medieval CPR: 41.92%) and St Peter's, Barton-on-Humber (CPR: 19.6%), as well as the overall estimated male and female CPR of 24.7% (Roberts and Cox 2003, 198) for the early medieval period. The TPR for all vertebrae is 35.7% (243/681), which is still higher than the TPR (16.6%, 736/4441) estimated for several combined early medieval sites (all non-specialist populations) from Britain (Roberts and Cox 2003, 198). Like Towton, Schmorl's nodes were more common in the thoracic spine. They were common among all age groups (Table 3.38).

Osteoarthritis

Osteoarthritis was observed on the apophyseal joints of the thoracic and lumbar spines of five discrete skeletons: mature adults 3800, 3803 and 3778, and unspecified adults 3688 and 3788. The CPR – 12.5% – is higher than Towton (7.7%, 3/39).

Spondylosis deformans

Spondylosis deformans was diagnosed after Rogers and Waldron (1995) by the presence of marginal osteophytosis and/or increased porosity on the surfaces of the vertebral bodies. The condition is caused by degeneration of the intervertebral disc and is associated with increasing age. A total of 19 (19/40, 47.5%) discrete skeletons had this condition, including three with increased porosity only, four with osteophytosis and increased porosity and 12

Table 3.39 Osteochondritis dissecans

Skeleton	*Age*	*Region*	*Location of lesion(s)*
3786	Adolescent	L elbow	L humerus: trochlea
3756	Adolescent	R knee; L ankle; R foot	R femur: lateral condyle; L talus: head; R medial cuneiform: superior portion of distal articular surface
3789	Adolescent	L elbow; R elbow	L humerus: trochlea; R humerus: trochlea
3794	Prime adult	L foot	L calcaneus: posterior facet; L cuboid: proximal articular surface
3809	Young adult	L foot; R foot	L metatarsal: head; R metatarsal: head
3719	Adult unspecified	L knee	L femur: medial condyle inferior surface
3773	Adult unspecified	L foot	L metatarsal: head
3796	Adolescent	L elbow; R elbow	L humerus: trochlea; R humerus: trochlea
3798	Adolescent	R elbow	R humerus: trochlea

with marginal osteophytosis only. The condition was most frequent in the thoracic and lumbar spines (Table 3.37) and primarily involved older individuals, suggesting a primarily age related aetiology in this group.

Circulatory disorders

Reduction or loss of the blood supply to the bone may result in necrosis (bone death) in the affected area and subsequent joint dysfunction. Examples of this in the Ridgeway Hill skeletons were present in the form of *osteochondritis dissecans* and Scheuermann's disease, two conditions that belong to a family of orthopaedic diseases known as osteochondrosis and primarily involve the joints of children and adolescents.

Osteochondritis dissecans

In the Ridgeway Hill skeletons *osteochronditis dissecans* was observed on nine individuals (9/40; 22.5%) and one isolated limb/extremity (Table 3.39). In this condition necrosis occurs in a small focal area on the convex surface of diarthrodial joints and results in partial or complete detachment of a segment of the subchondral bone and articular cartilage. The aetiology is not fully understood but it may be caused by low grade chronic trauma, micro-trauma and defective blood flow, rapid growth and developmental anomalies (Aufderheide and Rodríguez-Martín 1998, 81; Federico *et al*. 1990). Among the Ridgeway Hill skeletons joints affected were (from most to least frequent) those from the elbow, foot, knee and ankle (Figure 3.56) (Table 3.40). These include two defects that were possible cases only, being of mild expression (two femur condyles; skeletons 3756 and 3719); the others were otherwise consistent in their expression with those published in the palaeopathological literature (for example, Aufderheide and Rodríguez-Martín 1998). Discounting all possible defects the CPR reduces from 25% to 20% (8/40).

Not included in these statistics are eight cases of *pseudo osteochondritis*, that is a defect on the proximal joint surface of the first metatarsal phalanx (a concave surface and therefore not true *osteochondritis dissecans*) (Aufderheide and Rodríguez-Martín 1998, 82), observed on four from the right side (skeletons 3756, 3762, 3764 and 3792) and five from the left side (skeletons 3764, 3781, 3784, 3795, 3803). In addition, the same defect, but

Table 3.40 TPR of osteochondritis dissecans by skeletal region

	No. with lesion	*Total no. observed bones*	*%*
R elbow	3	34	8.8
L elbow	3	27	11.1
R knee	1	36	2.8
L knee	1	33	3.0
R ankle	0	31	0.0
L ankle	1	34	2.9
R foot	2	31	6.5
L foot	3	36	8.3

Fig. 3.56 Skeleton 3775, osteochondritis dissecans *in the left ankle (tibial facet of talus)*

on another concave joint surface – the patella (three cases, all right side) – was observed on skeletons 3775, 3795, 3796.

In modern populations, *osteochondritis dissecans*, which is most commonly seen in the femoral condyle, the talus and the elbow, affects more males than females and individuals aged between 10 and 25 years old (Aufderheide and Rodríguez-Martín 1998, 82-3). Predominant involvement of the elbows may be the result of strong activities involving the arms and upper body (Aufderheide and Rodríguez-Martín 1998). Generally, the condition does not cause symptoms in adolescents, apart from perhaps some clicking of the joint (Clanton and DeLee 1982). However, adults may suffer some pain, stiffness and joint instability (ibid.). Thus, the condition probably did not affect the daily lives of the majority of the Ridgeway Hill individuals with changes, because most were adolescents.

The CPR seen among the Ridgeway Hill skeletons is far higher than the CPR (1.5%, 22/1,432) calculated for 1,432 skeletons dating between *c* 410 and *c* 1050, from 12 British sites, by Roberts and Cox (2003, 209-10), regardless of whether the possible lesions are counted or not. It also far exceeds the CPR for adult male skeletons from Castle Dyke (1/51, 1.96%), Barton-upon-Humber (early phase: 13/510, 2.55%) and St Helen's, Fishergate (1/57, 1.75% – one pseudo lesion discounted) and the overall male and female prevalence for Wharram Percy (Anglo-Saxon to Post-medieval phases: 3/211, 1.42%). The Ridgeway Hill prevalence is even high compared with specialist groups, including Towton (1/39, 2.6%) and three Royal Naval hospital assemblages from Greenwich, Plymouth and Haslar (combined male CPR: 12.33%; Boston, in prep.). Among the latter, the combined male TPR for humeri and femurs was 19/858 (2.2%) compared with 6.9% (9/130) for Ridgeway Hill. Like Ridgeway Hill, the most commonly affected joint among the Royal Naval skeletons was the elbow (TPR: left 2.99%; right 2.87%). This was followed by the left knee (TPR: 2.71%), then the ankle (TPR: left 1.91%; right 1.49%) (Boston, forthcoming). Another specialist group, the men from the Tudor warship, the Mary Rose, also appeared to have had a lower CPR than Ridgeway Hill, but the rank order in which joints were affected was similar: twelve cases involved the elbow; eleven, the foot and six, the knee.

Scheuermann's disease

Scheuermann's disease involves the secondary ossification centres (the apophyseal rings) of the vertebral bodies which become eroded in the antero-lateral aspect as a result of impaired blood supply. Anterior body height becomes reduced and, in the majority of cases, a kyphopsis develops with an apex in the thoracic spine, sometimes also scoliosis (Aufderheide and Rodríguez-Martín 1998). The condition, which has an on-set of between approximately 12 and 18 years, has a strong genetic component in its aetiology (ibid.). In modern clinical literature the condition is sometimes reported to be more common among males than females (for example, Fisk *et al*. 1982), sometimes more females than males (for example, Segatto 2008) and sometimes it is considered to show no predilection for either sex (for example, Baker 1988).

No confirmed cases were observed among the Ridgeway Hill skeletons, because diagnosis rests on measuring wedging of the vertebrae, which was beyond the scope of the present work (and in some cases precluded by fragmentary vertebrae). However, possible cases include two discrete individuals, adolescent 3786 and older adult 3804, who had erosive lesions on the anterior-superior aspect of their thoracic/lumbar bodies. The changes on 3804 were accompanied by a loss of body height, but the vertebrae from 3786 were too fragmented to observe other changes. In addition to these possible cases, a further five individuals, including three adolescents (3754, 3756 and 3775) and two young adults (3700 and 3755) had similar changes.

Miscellaneous pathology

In a few cases lesions were undiagnosed because the changes were not consistent with a recognised condition and/or further investigation, including radiography, is required. These will be summarised here:

An erosive lesion (approximately 9 x 7mm), with smooth well-defined margins was present on the first thoracic body of skeleton 3805 (older adult), just inferior to the left costal facet. The floor of the lesion was made up of compact, but porous/vascular bone and there was no reactive/inflammatory new bone in or around the lesion. The lesion could relate to pathology involving the first rib, but this bone was not available for examination. Joint disease or infection are the possible diagnoses.

Lytic defects were identified on the distal left tibia and inferior talus joint surfaces of skeleton 3780 (adult unspecified). On the talus bone the lesion was accompanied by porosity, suggestive of localised inflammation, although this was relatively minor. No reactive bone accompanied the defect on the tibia. The changes may refer to *osteochondritis dissecans*, or possible infection involving the marrow cavity.

A large lytic lesion was also observed on the inferior surface of the 11th thoracic body of skeleton 3770 (prime adult). While this could refer to

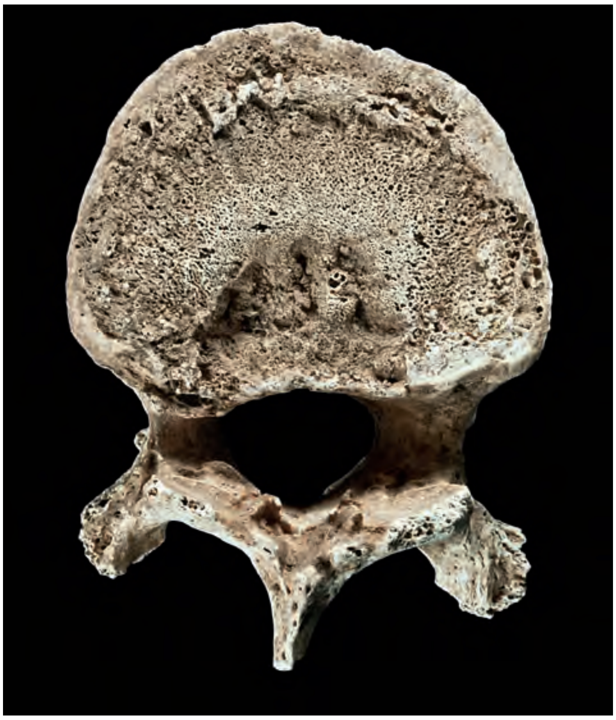


Fig. 3.57 Skeleton 3770, lytic lesion on the inferior body surface of the 11th thoracic vertebra caused by disc herniation

Schmorl's nodes, the lesion is not typical of this condition. It was located towards the back and had an irregular and nodular floor (Fig. 3.57). A differential diagnosis would be infection, although the fact that other vertebrae in this skeleton have Schmorl's nodes and that the margin of the lesion is similar to one such defect in the vertebra below, suggests that herniation is more likely.

Nodular, spiculated new bone was observed predominantly on the lateral portions (but within the epiphyseal rings) of the surfaces of some lumbar bodies, in particular the 4th and 5th of skeleton 3753 (young adult). The new bone did not appear to be reactive, although infection cannot be ruled out. The spiculated appearance is consistent with *spondylosis deformans*, although this would be unsual in a young indiviual (the skeleton was a young adult).

An altered joint morphology was noted in the distal femur of two skeletons. In 3792 (adult unspecified) the anterior surface of the right distal femur was reduced in size compared with that of the left, but there were no associated lesions, such as joint disease. In skeleton 3698 (adult unspecified) an undulating right articular surface of distal femur was noted, but again no associated lesions were observed. It is possible that the abnomalities on both skeletons had been caused by childhood trauma that had subsequently remodelled, but there was no macroscopic evidence for this. Radiography would be required to explore this further.

Trauma

Trauma refers to any injury or wound to the body that may affect the bone and/or soft tissues (Roberts 1991, 226). Weapon trauma, dislocations, ligament trauma manifested as new bone formation, *myositis ossificans* (ossification of muscle), subperiosteal haematomas and fractures are the main types of ante-mortem trauma that are recorded palaeopathologically.

The types of trauma observed in the present assemblage were healed, indirect fractures; *myositis ossificans*; a possible haematoma and peri-mortem weapon injuries. In addition, adolescent skeleton 3756 had a smooth, remodelled, linear defect on the lateral condyle of the right femur, consistent with healed sharp force weapon trauma. The articulating patella was not involved, however, making it difficult to conceive how a wound could have been sustained to this part of the femur without involvement of this bone.

Fractures

A fracture is defined as a complete or partial break in the discontinuity of bone (Roberts 1991, 226). Fractures may result from underlying pathology, repeated stress or acute injury (Roberts and Manchester 1995). Fractures occurring around the time of death, when the organic matrix of the bone is still present, are termed peri-mortem, while those occurring after death, when the organic matrix has decomposed are termed post-mortem. Ante-mortem fractures occur before death and may be identified based on evidence for healing in the form of re-modelled or re-modelling new bone. The identification of these different types of fracture in archaeological human bone holds enormous scope for furthering knowledge of the lives of past populations, including their social interactions, activities, socio-economic status and treatment of the dead. For example, certain types of ante- or peri-mortem fracture are indicative of inter-personal violence, while others could be from accidents (such as a fall from a height) (Crawford Adams 1983; Galloway 1999; Walker 1997). The alignment of an ante-mortem break and evidence for secondary pathology (among other changes) may indicate quality of diet and treatment (Grauer and Roberts 1996), while in certain burial contexts (such as a mass grave), some types of peri-mortem break may be associated with post-mortem dismemberment (Villa and Mahieu 1991; White 2003).

Ante-mortem fractures

In the present sample eight complete skeletons, seven limbs/extremities and six partial skeletons

Table 3.41 Summary of ante-mortem fractures (infra-cranial skeletons)

Skeleton No.	*Context type*	*Age category*	*Bone affected*	*Area affected*	*Status of healing*
3777	C	Mature adult	5th, 6th and 7th thoracic vertebrae	Vertebral bodies	Well healed
3787	C	Young adult	Right rib (unidentified)	Rib shaft	Well healed
3794	C	Prime adult	Right 11th rib	Rib neck region, just distal to the head	Well healed
3800	C	Mature adult	Left rib, left foot	Rib shaft and left calcaneus	Well healed
3803	C	Mature adult	Left rib	Rib shaft	Well healed
3810	C	Young adult	Right hand, possibly left tibia and possibly left foot	Third intermediate and distal hand phalanges; possibly left tibia proximal shaft and possibly left first and second metatarsals	Well healed
3806	C	Mature adult	Left tibia, left foot and right foot	Left talus posterior tubercle; left tibia (lateral condyle), right 5th proximal foot phalanx possibly left fifth metatarsal shaft	Well healed
3775	C	Adolescent	Possibly third lumbar vertebra	Inferior articular processes	Well healed
3779	L/ex	Adult unspec	Right foot	First right proximal foot phalanx lateral condyle	Well healed
3780	L/ex	Adult unspec	Left tibia	Distal left tibia joint surface (in region of medial malleolus)	Healing
3793	L/ex	Adult unspec	Left foot	? Second left proximal foot phalanx	Well healed
3802	L/ex	Adult unspec	Left foot	Distal end of left second proximal foot phalanx and left navicular	Well healed
3812	L/ex	Adult unspec	Left foot	Left navicular (dorsal lip)	Well healed
3792	L/ex	Adult unspec	Left foot	Left first metatarsal and possibly distal end of first proximal foot phalanx	Well healed
3784	L/ex	Adult unspec	Possibly left fibula	Possibly left proximal fibula	Well healed
3770	P	Prime adult	Right femur	Right proximal femur (2-part subtrochanteric fracture)	Well healed
3799	P	Adult unspec	Right rib	Rib shaft	Well healed
3811	P	Prime adult	Right clavicle	Clavicle, sternal end	Un-united
3783	P	Adult unspec	Right rib and left hand	Right rib shaft and distal end of left fifth proximal hand phalanx	Healing and well healed
3778	P	Mature adult	Right hand, left rib	Right fifth proximal interphalangeal joint of hand and left rib shaft	Well healed
3795	P	Prime adult	Possibly 5th lumbar vertebra	Fifth lumbar body (inferior)	Well healed

had sustained ante-mortem fractures to one or more bones, including two possible cases (complete skeleton 3775 and limb/extremity 3784) (Table 3.41). This equates to 35% (14/40) of all discrete individuals, or 32.5% (13/40) if the one possible case is excluded. These results suggest a much higher rate than has been calculated for the period by Roberts and Cox (2003, 202-203), who report an overall CPR of 5.9% (395 individuals). It is also higher than Warrham Percy (23.70% of males, all phases) and St John's College (9.0% of males) but much lower than Greenwich (84.5% of males) and similar to Towton (32.4%).

A total of 37 elements displayed macroscopic evidence for fracture, identified as a break in the continuity of the bone. However, of these, six require radiography to confirm their diagnosis. For the purposes of the present analysis, all of these elements have been counted as definite fractures.

Considering long bones only, 1.32% (6/455) had healed fractures. There is a growing corpus of data on long bone fracture rates for urban and rural medieval populations, and these provide a useful comparison with Ridgeway Hill. For urban populations, rates for males from six sites sit at between 4.7% and 21.1% (average: 9.7%) (Roberts and Grauer 1996, 538), while rates of 9.6% (Jarrow) and 21.5% (Raunds) have been reported for rural populations (Judd and Roberts 1999, 238). Thus, the Ridgeway Hill fracture rate would seem to be closer to urban than rural populations. This is the same rate as at Towton, where the long bone fracture rate was 1.7%.

Virtually all of the fractures were united and well healed healed (Table 3.41) suggesting that they had been sustained at least several months before death. In two cases – a hairline fracture to the distial left tibia (limb/extremity 3780) (Fig. 3.58) and a united complete fracture involving a right rib (partial skeleton 3783) (Fig. 3.59) – were healing at the time of death. On both bones the fracture margins displayed healed and unhealed new bone, suggesting that they had been sustained at least between one and three weeks prior to death, this being the minimum time it takes for macroscopic evidence for healing to appear on bone (Buikstra and Ubelaker 1994; Sauer 1998, 332). A further fracture involving the medial right clavicle (partial skeleton 3811) was un-united, implying continued use of the arm which had consequently impeded healing. However, the smaller size of this clavicle compared with the left side (which was also more robust), indicated disuse atrophy, the mobility of the shoulder having been affected by the fracture (Fig. 3.60).

The plotted distribution of elements with fractures suggests a tendency towards more bones from the lower limb than the upper limb to be involved (Fig. 3.61). The most frequently fractured elements, in order of most to least, were the left tibia (9.68%), left fibula (3.13%), right clavicle (3.13%), right femur (2.86%), left tarsals (2.52%), left metatarsals (2.5%) and left foot phalanges (1.46%). However, it should be noted one left tibia (skeleton 3810, Fig. 3.62) and one left fibula (skeleton 3784) require radiography to confirm the suspected presence of fractures in these bones. Interestingly, there was a complete absence of fractures involving forearm bones, as might be caused in situations of

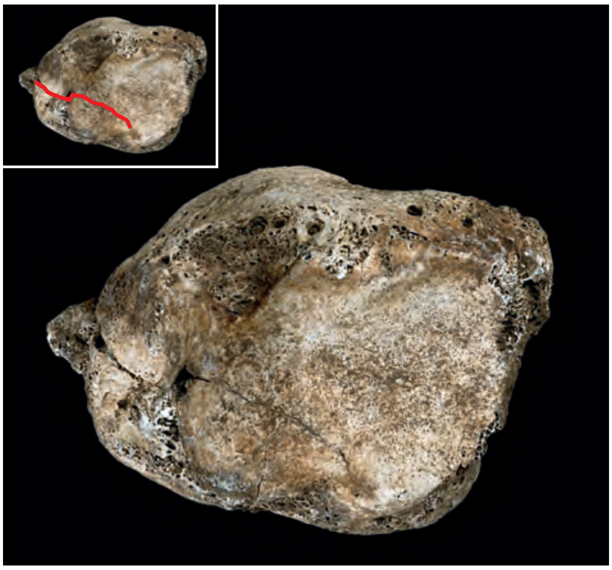


Fig. 3.58 Limb/extremity 3780, fracture on the left tibia distal articular surface (inferior view)

Fig. 3.59 Skeleton 3783, right rib shaft fragment exhibiting an un-united fracture

Fig. 3.60 Skeleton 3811, healed ununited fracture of the right clavicle, medial end (supero-anterior view)

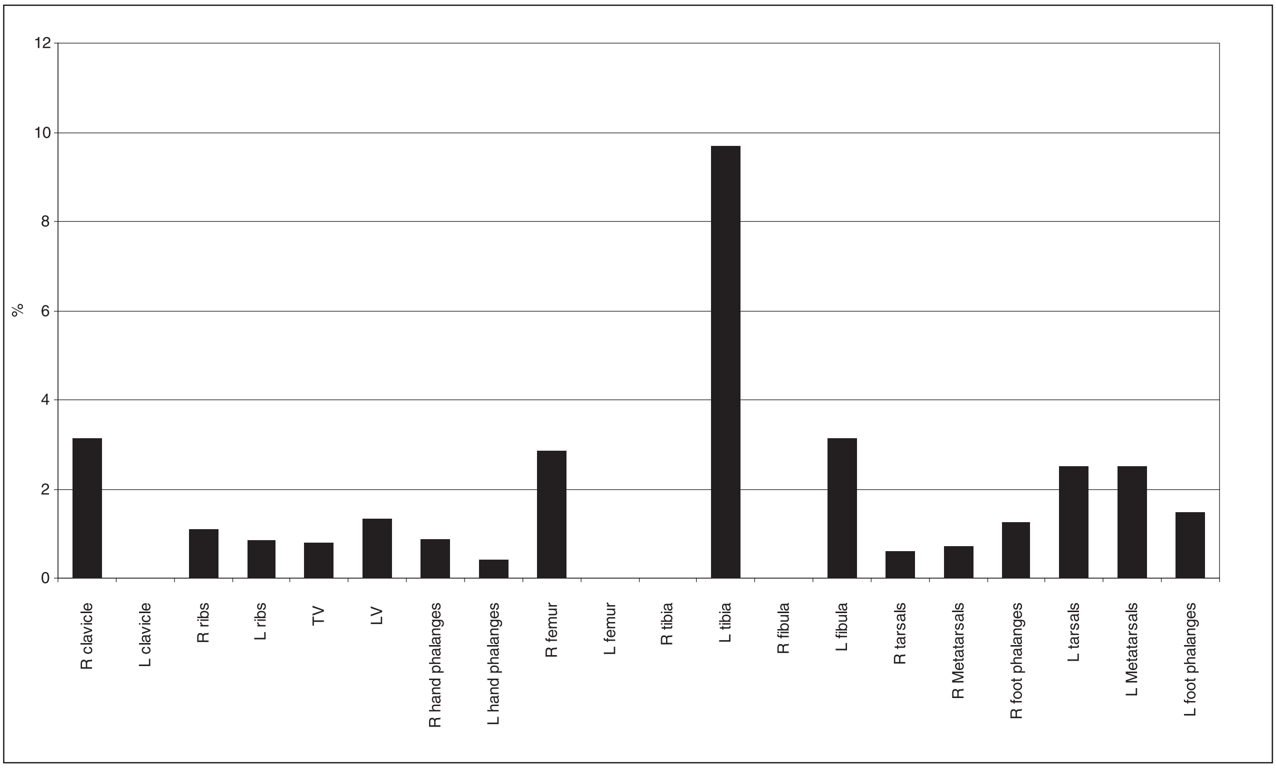


Fig. 3.61 Distribution of ante-mortem fractures by element (TPR; 40 discrete infra-cranial skeletons)

inter-personal violence and/or by a fall onto an outstretched hand.

The Ridgeway Hill distribution of fractures is different to comparative sites where there is a tendency for the clavicle, ribs, radius and ulna to be the most frequently affected elements, males and females combined (Grauer and Roberts 1996; Jurmain 1999). Judd and Roberts' study (1999, 238) of a medieval farming population observed most fractures among males in the clavicle (40.9%) and fibula (22.7%), followed by the humerus, radius, femur and tibia (9.1% each). At Wharram Percy (Mays 2007, 144-145, table 84), 22.3% (47/211) of adult males (10th–19th centuries) had healed fractures and among these ribs and vertebrae were the most common, with clavicles, the most frequently fractured long bone. At Towton, fractured elements, from most to least frequent, were the fibula (6.3%); clavicle (2.0%); humerus (1.7%); radius (1.6%); and tibia (1.4%).

Fractures involving the foot and ankle were observed in six isolated limbs/extremities and two complete skeletons. Those involving the tibia were observed on the proximal (3806) and distal joints (3780) and may occur when there is rotation of the body whilst the foot remains fixed to the ground (Galloway 1999, 198). The toes are ideally placed to collide with objects, while fractures involving the posterior talus may be caused by forced plantar flexion entrapping the bone between the calcaneus and posterior margin of the tibia (Galloway 1999, 210 – 222). Cortical avulsion of the dorsal lip of the navicular results from stresses placed on the talo-navicular capsule (Galloway 1999, 218). Stress fractures of the navicular bone are common among athletes and arise due to repetitive impact loading, such as when running, or prolonged muscular action on the bone when it has not been conditioned to that action (Kahn *et al*. 1994, 66).

Clavicle fractures were identified on one right clavicle only (partial skeleton 3811). Generally speaking fractures involving this bone may involve the sternal end of the shaft, the mid shaft, or the acromial end (the end nearest the scapula). Mid shaft fractures are the most common and are often associated with a blow as the result of a fall or being struck with an object (Galloway 1999, 115). Those involving the acromial end can be caused by displacement following a considerable pull on associated muscles, most often as the result of a blow to the shoulder (Galloway 1999, 115). Fractures that involve the sternal end, such as that observed here, tend to arise as the result of direct violence (ibid.).

Rib fractures were seen in seven complete skeletons, on a single rib fragment each. One of these involved the neck, or vertebral end, of the rib, while the remainder involved the shaft. Fractures that involve the shaft (rather than the neck) of the rib tend to be the result of interpersonal violence (Wells 1982a, b).

Fig. 3.62 *Skeleton 3810, probable trauma to the proximal shaft of the left tibia, posterior surface (posterior view)*

Fig. 3.63 *Skeleton 3770, healed fracture of right proximal femur (anterior view)*

Finally, one individual (skeleton 3770; Fig. 3.63) had sustained a two part subtrochanteric fracture to the proximal right femur. The fracture was remodelled, without signs of secondary infection or joint disease, indicating successful healing a long time before death. However the bone displayed shortening (its maximum length was 402mm, while that of the left femur was 448mm) indicating that, in terms of treatment, reduction and immobilisation had perhaps not been practised. These deformities would have been outwardly visible in life and would have altered the individual's gait, causing him to walk with a limp.

Myositis ossificans

Trauma involving the soft tissues may lead to *myositis ossificans traumatica*, a condition in which the soft tissue structures of the periosteum, the muscle and its fascial sheaths and/or the tendinous attachment of muscle to bone may ossify into a bony mass (Shipley 1940). On dry bone the condition may be diagnosed by the presence of isolated or attached lamellar bone fragments that have smooth, remodelled, borders and are often spiculated in appearance. This condition was seen on three individuals, one complete (3810; Fig. 3.64) and two partial skeletons (3770 and 3811), and two isolated limbs/extremities (3793 and 3784). In one case (skeleton 3811) the lesion accompanied a fracture. In one case the changes, which were present at the soleus origin of the left proximal fibula of 3784, may have been

Fig. 3.64 Skeleton 3810, probable trauma and secondary infection involving the right 1st and 2nd metatarsals

caused by an ossifying haematoma, rather than *myostitis ossificans*.

Ossified haematomas

No confirmed examples were identified. The only possible candidate is the fibula from 3784 and has been described above.

Peri-mortem trauma

A total of 27 discrete individuals (67.5%; 27/40), including 16 complete and 11 partial skeletons and three isolated limbs/extremities had one or more peri-mortem trauma lesions. These include sharp force trauma resulting from bladed assaults (27 individuals and isolated limbs/extremities 3771 and 3785) and indirect trauma (skeleton 3805, also with sharp force trauma, and isolated limb/extremities 3772 and, possibly, 3782). These primarily involved to the neck, shoulder, arm and hand regions. In addition, 11 complete skeletons had lesions that were classified as pseudo trauma, ten of which (skeleton 3697 excluded) also had sharp force lesions (Figs 3.65 and 3.66).

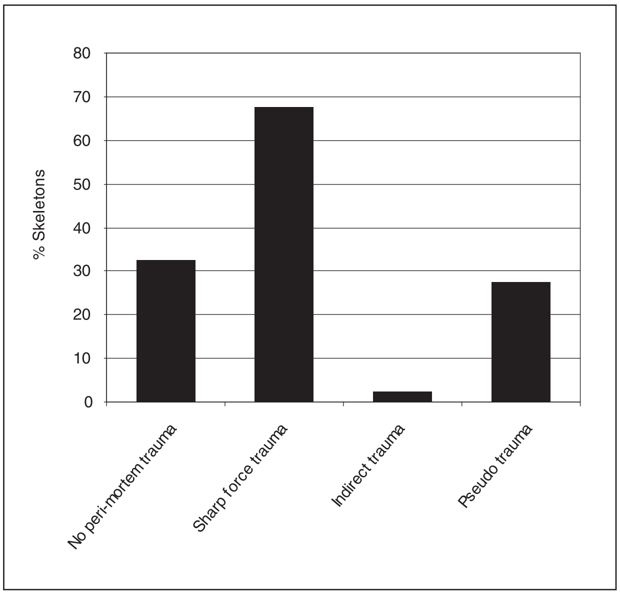


Fig. 3.65 Crude prevalence of peri-mortem trauma by type (40 discrete infra-cranial skeletons)

Sharp force trauma

A total of 67.5% of individuals (27/40; 16 complete and 11 partial skeletons) and two isolated limb/extremities (3771 and 3785) had one or more sharp force wounds involving one or more elements (Tables 3.42–3.45). Definite sharp force trauma was observed on a total of 91 elements (89 elements from discrete skeletons and two elements from isolated limb/extremities 3771 and 3785). This number increases to 96 (or 94 + 2) if possible sharp force trauma is also included. All possible sharp force lesions are excluded hereon.

Discrete skeletons had sustained sharp force wounds to between one and as many as 14 bones each, but most often between one and three. These are detailed in Tables 3.46 and 3.47, but it should be noted that the wound numbers do not refer to the order in which they were delivered and are merely for the purposes of description. The skeleton with the most affected elements was mature adult 3777, who had sustained a total of six wounds to one

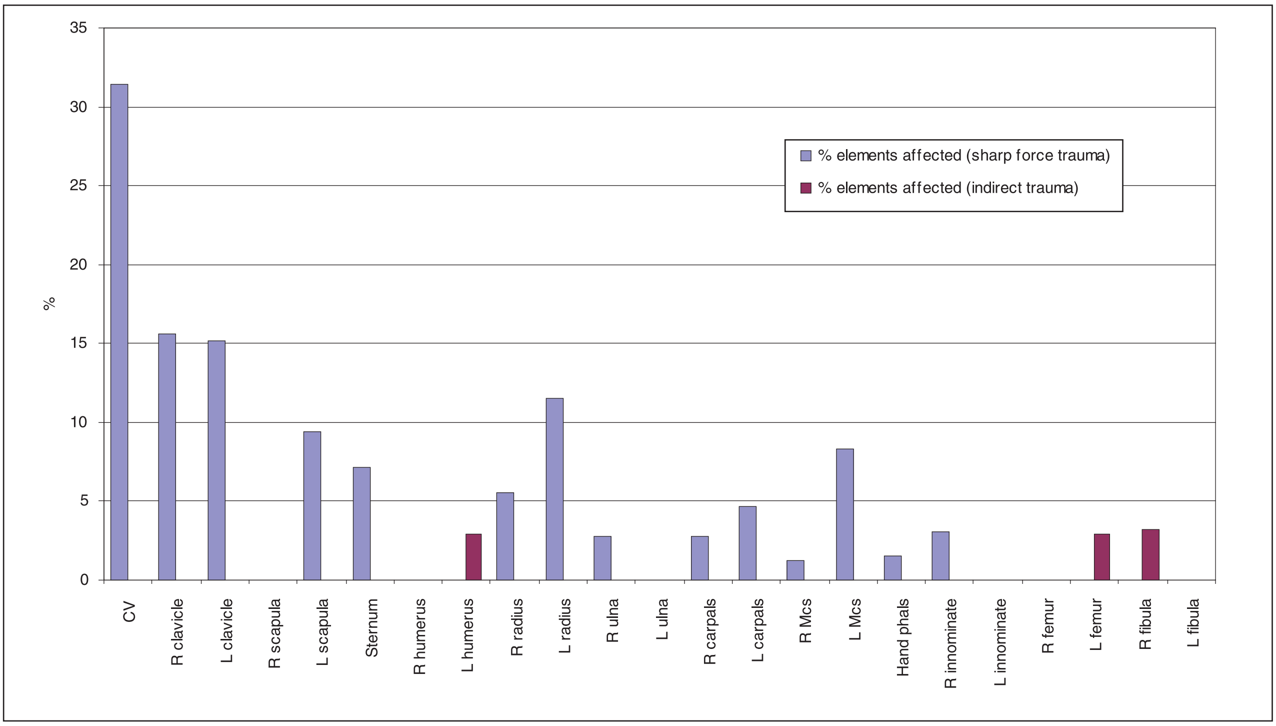


Fig. 3.66 Distribution of peri-mortem trauma by element (TPR; all discrete infra-cranial skeletons and isolated limbs/extremities)

Table 3.42 Peri-mortem sharp force trauma: number and percentage of elements affected amongst infra-cranial skeletons

Number of bones affected	*Number of discrete skeletons (%)*	*Skeletons affected*
1	11 (40.7)	3700, 3753, 3756, 3764, 3787, 3788, 3794, 3799, 3800, 3803, 3809
2	4 (14.8)	3781, 3789, 3796, 3805
3	5 (18.5)	3755, 3783, 3786, 3804, 3811
4	3 (11.1)	3689, 3715, 3763
8	1 (3.7)	3810
10	1 (3.7)	3778
11	1 (3.7)	3775
14	1 (3.7)	3777
	27	

Table 3.43 Peri-mortem sharp force trauma: number and percentage of skeletal wounds amongst infra-cranial skeletons

Number of skeletal wounds	*Number of discrete skeletons (%)*	*Skeletons affected*
1	10 (37)	3700, 3753, 3756, 3764, 3787, 3788, 3794, 3799, 3800, 3803
2	6 (22.2)	3755, 3781, 3783, 3804, 3805, 3809
3	3 (11.1)	3689, 3796, 3811
4	2 (7.4)	3778, 3786
5	2 (7.4)	3763, 3775
6	3 (11.1)	3777, 3789, 3810
7	1 (3.7)	3715
	27	

Table 3.44 Infra-cranial skeletons with peri-mortem sharp force trauma – distribution of lesions and number of elements affected (27 individuals and two isolated limbs/extremities)

Skeleton	*Context type*	*CV (Definite only)*	*Clavicle L*	*Clavicle R*	*Scapula L*	*Sternum*	*Rad L*	*Rad R*	*Ulna R*	*Carpals L*	*Carpals R*	*MCs L*	*MCs R*	*Hand phals L*	*Hand phals R*	*Hand phals unsided*	*Pelvis R*	*Total (elements)*	*Total (wounds)*
3689	P	1								1		2						4	3
3700	P	1																1	1
3715	P	3	1		1?													4 or 5	7
3753	C	1																1	1
3755	C	1	1		1													3	2
3756	P	1																1	1
3763	C	2	1	1		1?												4 or 5	5
3764	P	1																1	1
3771	L/ex							1										1	1
3775	C						1			5	2	2	1+1?					11 or 12	5
3777	C	1	1?		1?					4		5		3		1		14 or 16	6
3778	P			1				1	1		4	1			2			10	4
3781	C	2																2	2
3783	P	3																3	2
3785	L/ex														1			1	1
3786	P	2		1														3	4
3787	C	1																1	1
3788	C	1																1	1
3789	C		1	1														2	6
3794	C	1																1	1
3796	P	1					1											2	3
3799	P	1																1	1
3800	C	1																1	1
3803	C	1																1	1
3804	C	2															1	3	2
3805	C	2																2	2
3809	C	1																1	2
3810	C	5		1								1		1				8	6
3811	P	2					1											3	3
Totals		38	4+1?	5	1+2?	1?	3	2	1	10	6	11	1+1?	4	3	1	1	91/96	76

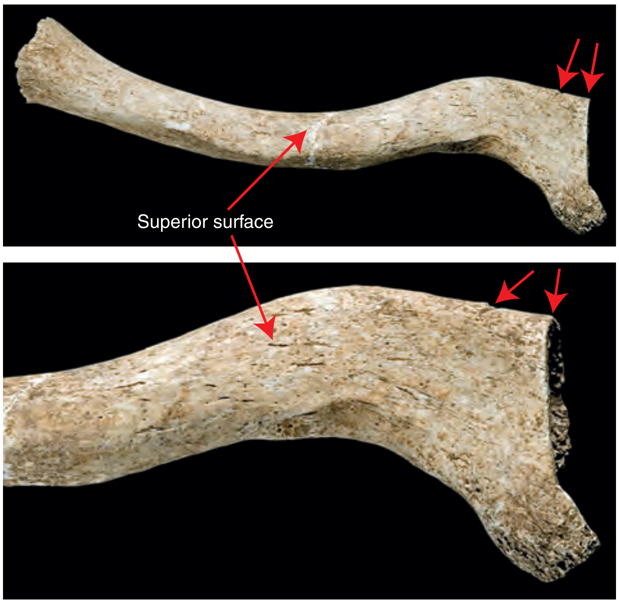
cervical vertebra and 13 bones from his left hand. Individuals 3775 and 3778 had sustained sharp force wounds to 11 and 10 bones each respectively. These involved hands and forearms and, in the case of 3778, also the shoulder.

At least 76 wounds were observed on a total of 91 affected elements (74 on 27 discrete skeletons and two on isolated limb/extremities 3771 and 3785). This suggests an average of approximately 1.85 wounds per individual (74 wounds divided by 40 discrete skeletons). It should be noted that this is a minimum number because the true number has been obscured by bone loss arising from the trauma, particularly to the cervical spine. Skeletons had between one and seven wounds each, but most had between one and three wounds (Table 3.43). The skeleton with the most wounds was 3715, a prime adult, whose left clavicle had sustained two wounds (Fig. 3.67) and whose first, second and third cervical vertebrae had sustained five wounds (Tables 3.46 and 3.47).

Wounds were classified according to whether they fully penetrated the full thickness of bones, penetrated the medullary/trabecular bone or were superficial cuts into the cortical bone (Tables 3.46 and 3.47). The most frequent type was fully penetrating (39 cervical wounds and 37 other post-cranial element wounds), followed by those that had penetrated into medullary/trabecular bone (four cervical wounds and 16 other post-cranial element wounds). There were three and nine superficial wounds to clavicles and other post-cranial elements respectively, and in three wounds (all cervical) they were a combination of fully penetrating and super-

Table 3.45 Distribution of sharp force trauma in the cervical spine (24 infra-cranial skeletons)

Skeleton No.	*Context type*	*Total no. CV with peri-mortem trauma – max (inc. ?s)*	*Total no. CV with peri-mortem trauma – min (exc. ?s)*	*C1*	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*
3689	P	1	1	0	0	1	0	0	0	0
3700	P	1	1	0	1	0	0	0	0	0
3715	P	3	3	1	1	1	0	0	0	0
3753	C	1	1	0	0	0	0	0	1	0
3755	C	6	1	0	?1	1	?1	?1	?1	?1
3756	P	1	1	0	0	0	0	1	0	0
3763	C	2	2	0	0	0	1	1	0	0
3764	P	4	1	0	0	0	1	?1	?1	?1
3777	C	3	1	0	0	1	?1	?1	0	0
3781	C	2	2	0	0	0	1	1	0	0
3783	P	3	3	0	0	1	1	1	0	0
3786	P	2	2	0	0	0	0	1	1	0
3787	C	1	1	0	0	1	0	0	0	0
3788	P	1	1	0	0	0	1	0	0	0
3794	C	1	1	0	0	1	0	0	0	0
3796	P	1	1	0	0	0	0	1	0	0
3799	P	2	1	0	1	?1	0	0	0	0
3800	C	1	1	0	1	0	0	0	0	0
3803	C	1	1	0	0	0	0	0	1	0
3804	C	2	2	0	0	0	0	0	1	1
3805	C	2	2	0	0	1	1	0	0	0
3809	C	1	1	0	0	0	0	1	0	0
3810	C	5	5	0	0	1	1	1	1	1
3811	P	2	2	0	0	0	1	1	0	0
Total inc. ?s/no. observed (%)				1/1 (100)	5/5 (100)	10/11 (90.91)	10/20 (50)	12/25 (48)	7/32 (21.88)	4/34 (11.76)
Total exc. ?s/no. observed (%)				1/1 (100)	4/5 (80)	9/11 (81.82)	8/20 (40)	9/25 (36)	5/32 (15.63)	2/34 (5.88)



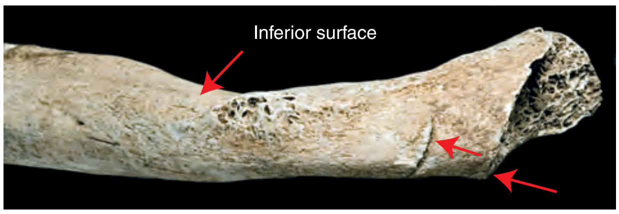
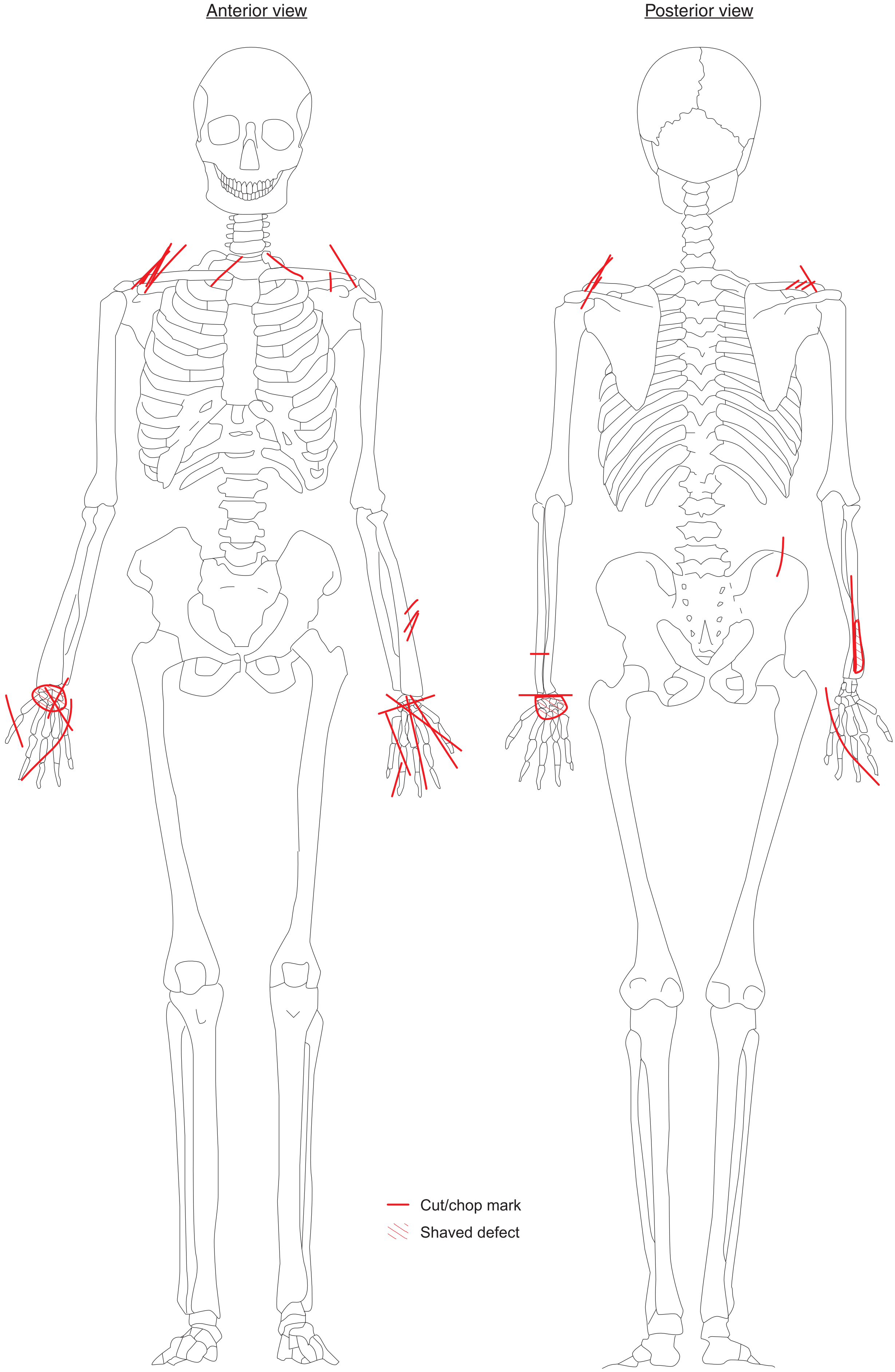


Fig. 3.67 Skeleton 3715, two peri-mortem sharp-force wounds to the left clavicle (top left and middle left: supero-anterior view; above: posterior view)

Fig. 3.68 (facing page) Distribution of peri-mortem sharp force trauma (excluding cervical vertebra trauma)



Anterior view
Posterior view
Cut/chop mark
Shaved defect

Table 3.46 Peri-mortem sharp force trauma (infra-cranial skeletons) – excludes cervical vertebrae

(N.B. Direction of blow/blade is given in terms of the bones lying in anatomical position. It does not take account of the fact the arms/hands, for example, could have been held in a variety of positions when the impact occurred (e.g. held up in front of face, out to the sides, up over the top of the head)

Skeleton No.	*Total no. wounds/blows*	*No. elements involved*	*Skeletal region*		*Bones affected*	*Angle of wound (oblique/perpendicular)*
3689	1	3		L hand	L MC2	Oblique
					L MC3	Oblique
					L capitate	Oblique
3715	2	1	Wound 1	L shoulder	L clavicle	Oblique
			Wound 2	L shoulder	L clavicle	Oblique
3755	1	2		L shoulder	L clavicle	Oblique
					L scapula	Oblique
3763	2	2	Wound 1	L shoulder	L clavicle	Oblique
			Wound 2	R shoulder	R clavicle	Oblique
3771	1	1		R forearm	R radius	Oblique
3775	5	11	Wound 1	R hand	R hamate	Oblique
			Wound 2	R hand	R capitate	Oblique
					R hamate	Oblique
					R MC5	Oblique
			Wound 3	L hand	L scaphoid	Oblique
					L lunate	Oblique
			Wound 4	L hand	L scaphoid	Oblique
					L hamate	Oblique
					L capitate	Oblique
					L trapezoid	Oblique
					L MC2	Oblique
					L MC3	Oblique
			Wound 5	L forearm	L radius	Oblique
3777	5	13	Wound 1	L hand	L distal phalanx 1	Oblique
					L proximal phalanx 1	Oblique
					L MC1	Oblique
					L trapezium	Oblique
					L MC2	Oblique
					Scaphoid	Oblique
			Wound 2	L hand	L MC3	Oblique
					L MC4	Oblique
			Wound 3	L hand	L hamate	Oblique
					L trapezoid	Oblique
			Wound 4	L hand	L proximal phalanx 4	Oblique
					L MC5	Oblique
			Wound 5	L hand	L MC4	Oblique
3778	4	10	Wound 1	R shoulder	R clavicle	Oblique
			Wound 2	R forearm	R radius	Oblique
					R ulna	Oblique
			Wound 3	R hand	R proximal phalanx 3	Oblique
					R proximal phalanx 4	Oblique
					R MC5	Oblique
			Wound 4	R hand	R trapezium	Oblique
					R capitate	Oblique

Depth of wound (superficial/ into medullary or trabeculae/ fully penetrating)	*Bone surface affected*	*Direction of blow/blade (from anatomical position)*
Fully penetrating	Lateral surface of mid shaft to medial surface of proximal shaft	?Infero-lateral to supero-medial
Fully penetrating	Lateral edge of proximal end	
Fully penetrating	Dorso-medial surface	
Superficial	Posterior surface of lateral end	Lateral to medial
Fully penetrating	Lateral end	?Postero-medial to antero-lateral
Into medullary / trabeculae	Superior surface of lateral end	Supero-medial to infero-lateral, from posterior
Into medullary / trabeculae	Posterior surface of acromion process	
Into medullary / trabeculae	Superior surface of medial shaft	Supero-medial to infero-lateral
Into medullary / trabeculae	Medial articular surface	Antero-medial to postero-lateral
Superficial (longitudinal shaved defect)	Posterior surface of mid to distal shaft	?Superior to inferior / inferior to superior
Into medullary / trabeculae	Medial surface of hamate hook	Medial to lateral
Into medullary / trabeculae	Medial surface	Medial to lateral
Fully penetrating	Supero-lateral surface	
Fully penetrating	Lateral surface of the proximal end	
Fully penetrating	Dorsal surface	Inferior to superior
Into medullary / trabeculae	Dorsal surface	
Fully penetrating	Bisected	?
Fully penetrating	Dorsal surface	
Fully penetrating	Dorsal surface	
Fully penetrating	Dorsal surface	
Fully penetrating	Dorsal surface of proximal end	
Fully penetrating	Dorsal surface of proximal end	
Into medullary / trabeculae	Posterior surface of distal shaft	Superior to inferior
Fully penetrating	Bisected longitudinally	Inferior to superior
Fully penetrating	Medial condyle	
Fully penetrating	Medial surface of head	
Fully penetrating	Distal portion	
Fully penetrating	Mid – proximal shaft	
Fully penetrating	Distal surface	
Fully penetrating	Palmar surface of head	Inferior to superior
Fully penetrating	Lateral surfaces of head & base	
Fully penetrating	Palmar surface	?
Fully penetrating	Palmar surface	
Fully penetrating	Lateral surface of midshaft to medial surface of base	Inferior to superior
Fully penetrating	Lateral surface of head	
Into medullary / trabeculae	Distal surface of head	Inferior to superior
Into medullary / trabeculae	Antero-superior surface of lateral shaft	Supero-lateral to infero-medial
Superficial	Postero-medial surface of distal shaft	?Inferior to superior or superior to inferior; from posterior
Superficial	Postero-lateral surface of midshaft	
Fully penetrating	Lateral surface of head to medial surface of distal shaft	Infero-lateral to supero-medial
Fully penetrating	Proximal shaft	
Fully penetrating	Head and medial surface of base	
Fully penetrating	Medial portion	?
Fully penetrating	Palmar portion	

Table 3.46 (continued)

Skeleton No.	Total no. wounds/ blows	No. elements involved	Skeletal region		Bones affected	Angle of wound (oblique/perpendicular)
					R scaphoid	Oblique
					R hamate	Oblique
3785	1	1		R hand	R proximal phalanx 1	Oblique
3786	2	1	Wound 1	R shoulder	R clavicle	Oblique
			Wound 2	R shoulder	R clavicle	Oblique
3789	6	2	Wound 1	L shoulder	L clavicle	Perpendicular
			Wound 2	R shoulder	R clavicle	Oblique
			Wound 3	R shoulder	R clavicle	Oblique
			Wound 4	R shoulder	R clavicle	Oblique
			Wound 5	R shoulder	R clavicle	Oblique
			Wound 6	R shoulder	R clavicle	Oblique
3796	2	1	Wound 1	L forearm	L radius	Oblique
			Wound 2	L forearm	L radius	Oblique
3804	1	1		R lower limb	R ilium	Oblique
3810	3	3	Wound 1	R shoulder	R clavicle	Oblique
			Wound 2	L hand	L MC2	Oblique
			Wound 3	L hand	L proximal phalanx 3	Oblique
3811	1	1		L forearm	L radius	Oblique

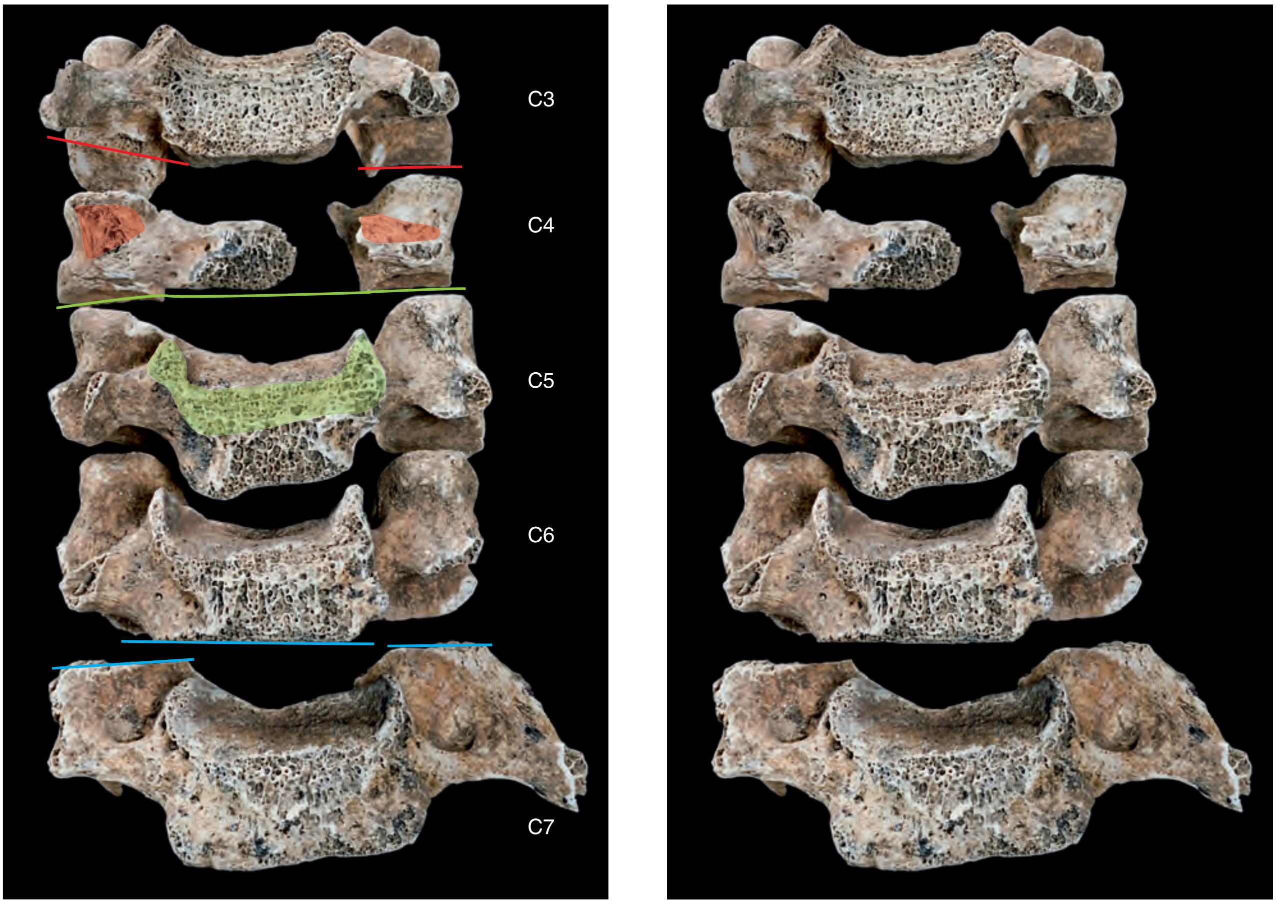


Fig. 3.69 (above) Skeleton 3810, peri-mortem sharp-force trauma to the cervical spine (anterior view) – at least three separate wounds (coloured red, green and blue)

Depth of wound (superficial/ into medullary or trabeculae/ fully penetrating)	*Bone surface affected*	*Direction of blow/blade (from anatomical position)*
Fully penetrating	Palmar surface of body	
Fully penetrating	Bisected	
Fully penetrating	Lateral surface of proximal shaft to medial surface of distal shaft	?Supero-lateral to infero-medial or infero-medial to supero-lateral
Superficial	Superior surface of lateral end	Medial to lateral
Fully penetrating	Mid to lateral shaft	Supero-medial to infero-lateral
Superficial	Inferior surface of lateral shaft	Inferior to superior
Superficial	Superior surface of lateral end	Supero-medial to infero-lateral
Fully penetrating	Lateral end	?Supero-medial to infero-lateral
Into medullary / trabeculae	Posterior surface of mid to lateral shaft	Postero-lateral to antero-medial
Into medullary / trabeculae	Posterior surface of mid to lateral shaft	Postero-lateral to antero-medial
Into medullary / trabeculae	Posterior surface of mid to lateral shaft	Postero-lateral to antero-medial
Superficial	Lateral surface of midshaft	Supero-lateral to infero-medial
Into medullary / trabeculae	Lateral surface of midshaft	Supero-lateral to infero-medial
Into medullary / trabeculae	Posterior surface of superior aspect	Posterior to anterior
Into medullary / trabeculae	Superior surface of lateral end	Anterior supero-medial to posterior infero-lateral
Fully penetrating	Medial surface of midshaft to centre of base	Infero-medial to supero-lateral
Fully penetrating	Medial condyle	Infero-lateral to supero-medial
Superficial	Lateral surface of mid to distal shaft	Supero-lateral to infero-medial

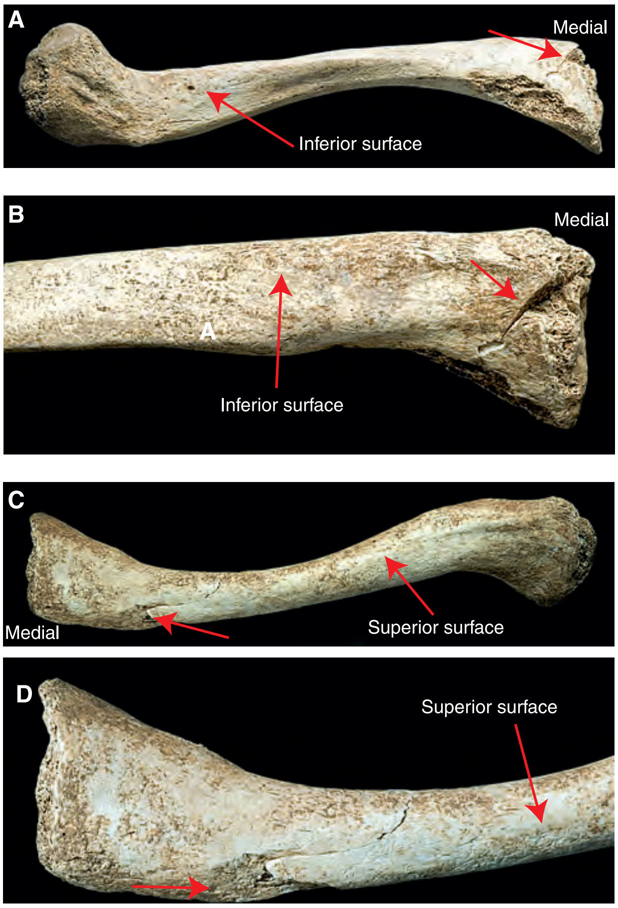


Fig. 3.70 (left) Skeleton 3763, peri-mortem sharp-force trauma to the right (a and b) and left (c and d) clavicles

Fig. 3.71 Skeleton 3755, peri-mortem sharp-force trauma to the left clavicle and scapula, single wound, shown by red line (postero-superior view)

Table 3.47 Peri-mortem sharp force trauma (infra-cranial skeletons) – cervical vertebrae

Skeleton No.	*Total no. wounds/ blows*	*No. CV involved*	*Cervical vertebrae affected*		*Angle of wound (oblique/horizontal)*	*Depth of wound (superficial/ into trabeculae/fully penetrating)*
3689	2	1	Wound 1	C3	Oblique	Fully penetrating
			Wound 2	C3	Horizontal	Fully penetrating
3700	1	1		C2	Horizontal	Fully penetrating
3715	5	3	Wound 1	C1	Oblique	Fully penetrating

Fig. 3.72 Skeleton 3775, peri-mortem sharp force trauma to left radius, shaved defect

Fig. 3.73 (right) Skeleton 3775, peri-mortem sharp force trauma to the left (dorsal view) and right (palmar view) hands. Details of trauma to right haemate shown below

Bone surface affected	Direction of blow/blade(from anatomical position)
Superior surface of R superior facet	?
Inferior tip of spinous process	?
Medial aspects of the L & R superior facets and superior body/odontoid	?
Superior surface of anterior arch	?

continued overleaf

ficial. In some cases, single wounds to more than one bone were observed to reach different depths, reflecting the changing angle of the blade as it interacted with the bone (for example, 3715 wound number 2 to the first and second cervical vertebrae; Table 3.47). This explains why these numbers for the different wounds depths, when totalled, do not equal the total number of wounds.

The most frequently affected elements were cervical vertebrae, clavicles and scapulae (Figs 3.66 and 3.68). In total, 24 individuals (11 partial and 13 complete skeletons) had sharp force wounds involving cervical vertebrae, most commonly the first, second and third, but also the fourth, fifth, sixth and seventh (Table 3.45) (Fig. 3.69). A total of 39 (39/124; 31.45%) cervical vertebrae had one or more lesions, or 49 (39.52%) if 10 possible wounds (all observed on skeletons with definite wounds as well) are included.

The vast majority of wounds on the cervical vertebrae were fully penetrating, although superficial cuts and chops/cuts that only went into the trabecular bone were also observed (Table 3.47). In many cases, the direction of the wounds could not be determined owing to bone loss. Where direction could be observed, six were from behind (often the posterior right) and six were from the front (often the anterior left) (Table 3.47).

Cervical wounds were often accompanied by sharp force lesions involving clavicles and scapulae, which involved eight and three individuals respectively (Table 3.44). Clavicles were affected bilaterally on two individuals (Fig. 3.70), while on three just the left side was affected and on a further three just the right side was affected (all affected individuals had both clavicles surviving). All but one of the individuals also had lesions on their cervical spines. Three individuals had sharp force lesions involving the scapula, all on the left side. These individuals also had lesions on the clavicles and cervical vertebrae (Fig. 3.71). The vast majority of clavicle and scapula wounds were substantial cuts / chops and were probably the continuation of wounds aimed at the head and neck region, because they were associated with lesions on cervical vertebrae and/or their angle strongly suggested associated cranial skull wounds (Table 3.46).

Most other elements with sharp force trauma were forearms, wrists and hands and reflect a predilection for the left side (Table 3.44, Fig. 3.23). Four individuals (10%; 4/40) and one isolated limb/extremity had sharp force trauma involving the forearms. The posterior, distal shaft of the left radius belonging to complete skeleton 3775 had a shaved defect from a bladed instrument that had probably been delivered

Fig. 3.74 Limb/extremity 3771, peri-mortem sharp-force trauma to right radius, shaved defect (posterior view)

Table 3.47 continued

Skeleton No.	*Total no. wounds/ blows*	*No. CV involved*	*Cervical vertebrae affected*		*Angle of wound (oblique/horizontal)*	*Depth of wound (superficial/ into trabeculae/fully penetrating)*
				C2	Oblique	Fully penetrating
			Wound 2	C1	Oblique	Fully penetrating
				C2	Oblique	Into trabeculae
			Wound 3	C2	Oblique	Into trabeculae
			Wound 4	C2	Oblique	Into trabeculae
			Wound 5	C3	Oblique	Fully penetrating
3753	1	1		C6	Horizontal	Fully penetrating
3755	1	1		C3	Horizontal	Fully penetrating
3756	1	1		C5	Horizontal	Fully penetrating
3763	3	2	Wound 1	C4	Horizontal	Fully penetrating
			Wound 2	C4	Horizontal	Fully penetrating
			Wound 3	C4	Horizontal	Fully penetrating
				C5	Horizontal	Superficial
3764	1	1		C4	Oblique	Superficial
3777	1	1		C3	Horizontal	Fully penetrating
3781	2	2	Wound 1	C4	Oblique	Fully penetrating
			Wound 2	C4	Horizontal	Fully penetrating
				C5	Horizontal	Fully penetrating
3783	2	3	Wound 1	C3	Horizontal	Fully penetrating
			Wound 2	C4	Oblique	Fully penetrating
				C5	Oblique	Fully penetrating
3786	2	2	Wound 1	C5	Oblique	Fully penetrating
			Wound 2	C6	Horizontal	Fully penetrating
3787	1	1		C3	Horizontal	Fully penetrating
3788	1	1		C4	Oblique	Fully penetrating
3794	1	1		C3	Oblique	Fully penetrating
3796	1	1		C5	Oblique	Fully penetrating
3799	1	1		C2	Horizontal	Into trabeculae
3800	1	1		C2	Oblique	Fully penetrating
3803	1	1		C6	Oblique	Fully penetrating
3804	1	2		C6	Oblique	Fully penetrating
				C7	Oblique	Fully penetrating
3805	2	2	Wound 1	C3	Oblique	Fully penetrating
			Wound 2	C4	Oblique	Fully penetrating
3809	2	1	Wound 1	C5	Horizontal	Fully penetrating
			Wound 2	C5	Oblique	Fully penetrating (arch)/ superficial (body)
3810	3	5	Wound 1	C3	Oblique	Superficial
				C4	Oblique	Fully penetrating
			Wound 2	C4	Oblique	Fully penetrating (body)/ superficial (arch)
				C5	Oblique	Fully penetrating
			Wound 3	C6	Oblique	Fully penetrating (body)/ superficial (arch)
				C7	Oblique	Fully penetrating
3811	2	2	Wound 1	C4	Horizontal	Fully penetrating
			Wound 2	C5	Oblique	Fully penetrating

Bone surface affected	*Direction of blow/blade(from anatomical position)*
Superior tip of odontoid	
Inferior surface of CV1 L inferior facet	Postero-superior to antero-inferior
Posterior surface of odontoid	
Medial surface of R superior facet and superior surface of L lamina, just inferior to the L superior facet	R postero-superior to L antero-inferior
Superior surface of L lamina, just inferior to wound 3	R postero-superior to L antero-inferior
Inferior surface of R arch and spinous process	R postero-superior to L antero-inferior
Superior surface of body and arch (uncinate processes and superior facets)	?
R arch (inferior portion present only)	?
Superior surface of R lamina and R superior facet	?
Superior surface of the L superior facet	?
Superior surfaces of the L lamina and R superior facet	?
Inferior surface of spinous process and R inferior facet	Posterior to anterior
Posterior surface of the R superior facet	
Anterior surface of body	Anterior to posterior
R superior facet and uncinate process	?
Superior surface of L superior facet	?
Inferior tip of L inferior facet	?
Superior tip of L superior facet	
Inferior surface of L arch (inferior portion of L inferior facet present only)	?
Superior surface of R lamina and superior facet	?
Tip of L superior facet	
Through body (almost in horizontal plane)	?
Inferior portion of L inferior facet	?
Superior surface of R side of body	L antero-lateral to R postero-lateral
Superior surface of R lamina and postero-superior region of body	?
Superior surfaces of body and L arch	?
Superior tip of R superior facet, L superior facet and superior surface of L transverse process	?
Superior surface of the L & R arch	Anterior to posterior
R superior facet, odontoid and supero-medial aspect of the L superior facet	?
Tip of R superior facet	?
Tip of the R superior facet	?
Superior surface of spinous process tip	
R lamina	?
L lamina	?
L superior facet and uncinate process	?
Medial aspect of R superior facet and lamina, and through L lamina (with superficial cut into posterior surface of body)	R postero-superior to L antero-inferior
Anterior surfaces of the L & R inferior processes	Antero-inferior to postero-superior
L & R superior facets	
Inferior surface of body (with superficial cut in the anterior surface of L & R arch)	Antero-inferior to postero-superior
Antero-superior margin of body	
Antero-inferior margin of body and the tips of the L & R inferior facets (with superficial cut in the antero-inferior surface of the spinous process)	Antero-inferior to postero-superior
Tips of the L & R superior facets	
Superior surface of R lamina	?
Tip of R superior facet, superior surface of the left side of the body and the L superior facet	?

Fig. 3.75 Skeleton 3778, peri-mortem sharp-force trauma to right radius and ulna, superficial cuts (posterior view)

from the front at an oblique angle, travelling proximal to distal and halting within the medullary cavity (Fig. 3.72). Radiating fractures extended from the lesion inferiorly and posteriorly. The same individual had also sustained at least two additional blows to the right and left hands and wrists which had resulted in chops to the carpals and metacarpals, in some cases completely sectioning the bones and removing slivers of bone (see catalogue for full description) (Fig. 3.73). These wounds were consistent with injuries that had been delivered by someone wielding a blade from the front or side of a victim whose hands had been held up to shield their head or face.

On the distal right radius (posterior surface) of limb/extremity 3771 a piece of bone had been removed longitudinally by a single blow from a blade (Fig. 3.74). Measuring 71mm superior to inferior and 18mm medial to lateral, it was quite fine because the cortical bone had not been completely penetrated, consistent with a shaved defect. It could

Fig. 3.76 Skeleton 3778, peri-mortem sharp-force trauma to right hand (palmar view)

Fig. 3.77 Skeleton 3796, peri-mortem sharp-force trauma to the left radius, a superficial cut and a cut into the medullary (lateral view)

have been sustained from the front or from behind by a blade travelling in a superior to inferior or inferior to superior direction. Under magnification striations were visible along the length of the lesion and possibly refer to imperfections in the blade. None of the hand bones were involved.

The right radius (postero-medial aspect) and ulna (postero-lateral aspect) of partial skeleton 3778 had sustained transverse cuts on the distal third of their shafts, both at the same level indicating that they had been caused by a single blow with a blade that had impacted at a 120°(ulna) and 90° angle (radius), had penetrated the cortical bone and stopped (Fig. 3.75). Both cuts were *c* 35-40mm long (superior to inferior) and were notably wide (*c* 3mm) compared with other cuts observed on the rest of the assemblage. They had possibly been delivered from behind by an individual wielding a blade travelling in a superior to inferior or inferior to superior direction. Multiple bladed injuries had also been delivered to the dorsal and ventral aspects of the same individual's right wrist and hand (carpals and phalanges), which had suffered areas of peri-mortem bone loss (Fig. 3.76).

Complete skeleton 3796 had sustained two oblique, transverse wounds one above the other, 13mm apart, on the lateral surface of the left radial mid-shaft (Fig. 3.77). The inferior chop had *just* penetrated the full depth of the cortex, while the superior wound had only cut part way into the cortex. Their angle suggests that they had been delivered from the front by a blade travelling in a superior to inferior direction, either when the arm was raised in defence, or when it was by the individual's side. No other forearm or hand bones had sustained sharp force trauma.

Lastly, complete skeleton 3811 had a probable single, transverse, oblique cut (approximately 5mm long) on the lateral aspect of their left radius (mid to distal end of the shaft) (Fig. 3.78). The superficial defect appeared to have been delivered from the front, travelling from the direction of the elbow towards the hand. There were no other injuries on the forearms or hands of this individual.

A total of five discrete individuals (5/40; 10%) had sustained sharp force injuries to their wrists and/or hands. In addition to 3775 and 3778 described above this includes complete skeletons 3777 and 3810, and partial skeleton 3689. Four carpals, all five metacarpals and three phalanges from the left hand of 3777 had multi-directional sharp force injuries that had completely sliced through the bones (Fig. 3.79). Two unsided phalanges had also sustained complete chops and therefore it is possible that the right hand had also been involved. On skeleton 3810, the left second

Fig. 3.78 (left) Skeleton 3811, peri-mortem sharp-force trauma to the left radius, superficial cut (lateral view)

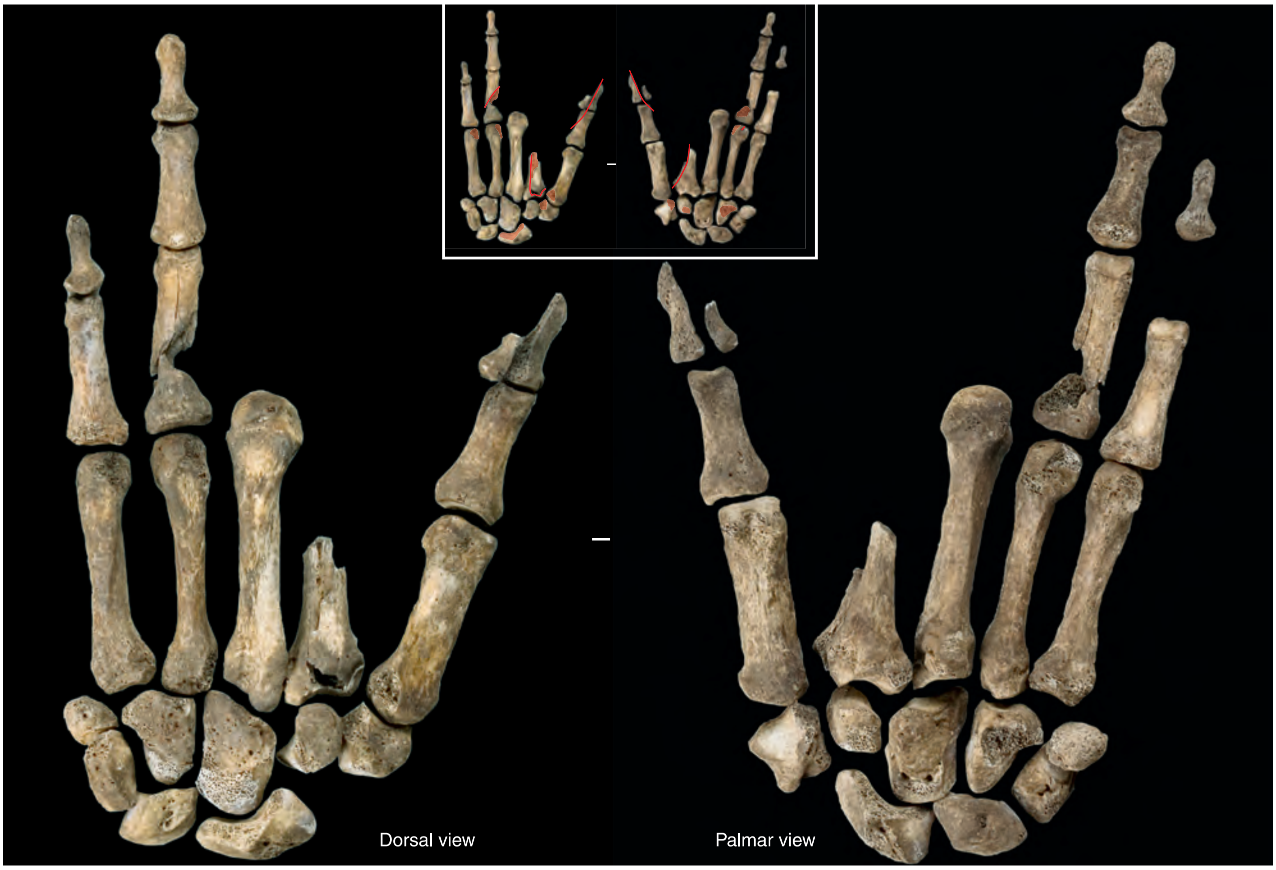


Fig. 3.79 (above) Skeleton 3777, peri-mortem sharp-force trauma affecting the left hand

metacarpal had been completely chopped through longitudinally part-way along the mid-shaft. The blow that had caused this lesion was of sufficient force for the fracture to continue up the mid-shaft and through to the proximal joint surface, where it terminated (Fig. 3.80). The distal articular surface of a proximal hand phalanx (possibly second) had also been completely bisected by a sharp instrument. Lastly, 3689 had fully penetrating blade injuries involving his left second, third and (possibly) fourth metacarpals.

In addition to these discrete skeletons, a single lesion was observed on the right hand of limb/ extremity 3785. Here, the proximal phalanx of the first metacarpal had been completely sectioned by an oblique chop through the mid-shaft (Fig. 3.81). All other surviving bones – the first metacarpal and distal phalanx – had been spared.

Sharp force trauma involving areas besides the neck, hands and forearm regions was rare. During excavation complete skeleton 3763 was observed to have had a linear defect with depressed cortical bone on the sternum (Fig. 3.82). Although the margins were not very sharp, their appearance was

Fig. 3.80 (left) Skeleton 3810, peri-mortem sharp-force trauma affecting the left hand (palmar view)

Fig. 3.81 Skeleton 3785, peri-mortem sharp-force trauma affecting the left hand (dorsal view)

otherwise consistent with a bladed instrument. The bone fragmented upon recovery, precluding more detailed examination and therefore this case has been classified as possible sharp force trauma. Another complete skeleton (3804) had a deep 'v' shaped cleft/chop mark on the posterior aspect of the right iliac crest which was *c* 5mm medial to lateral and *c* 7mm superior to inferior (Fig. 3.83). Crushed and smeared cortical bone was present on the internal surface of the defect. Analysis of the defect was hindered by the extremely fragmentary condition of the bone and therefore it is not known whether any other parts of this innominate bone (or the rest of the pelvis) had been affected by the trauma. This lesion is similar to Towton 42, a 26–35 year-old male who had a piece of metal embedded in his right iliac crest (Novak 2000, 264). However, in the present case no metal was found in the wound, which has a sharper profile.

Compared with Ridgeway Hill, a higher average number of post-cranial wounds (blunt and sharp force wounds) was identified among the Towton skeletons (2.2 compared with 1.85), but the number of discrete skeletons affected was lower (33% compared with 67.5%). These individuals had sustained between one and nine post-cranial skeletal wounds each, although, like Ridgeway Hill, two and three wounds each was seen among the majority. Fewer post-cranial blunt and sharp force wounds (43 compared with 76) were present on the entire assemblage of discrete and disarticulated skeletons combined. Sharp force injuries (all blade) were the most frequent. The distribution of post-cranial wounds showed a predilection for the forearms and hands.

At St John's College, an even higher average number (3.5) of post-cranial wounds per individual, than Ridgeway Hill was observed. Here, more discrete skeletons (76.5% compared with 67.5%) had

Fig. 3.82 Skeleton 3763, possible peri-mortem sharp force trauma to the sternum (photographs taken during excavation). Viewed from the anterior and in cross-section

post-cranial wounds, of which between one and ten per skeleton were noted (although the majority had two or four). At the assemblage level, 31 contexts (discrete skeletons and disarticulated bones pooled) had a total of 106 sharp force wounds, which involved a total of 93 elements. Blade, puncture and projectile sharp force traumas were observed, but blade trauma was the most frequent. The most

Fig. 3.83 Skeleton 3804, possible peri-mortem sharp-force trauma to the right ilium (posterior view)

Fig. 3.84 Skeleton 3805, peri-mortem helical fracture of the left femoral shaft. Left to right: anterior, medial and posterior views

frequently affected skeletal region was the back, followed by the legs, arms and neck.

Only blade wounds were observed among the Swedish warriors form Uppsala and included a total of 11 sharp force post-cranial wounds. These involved three tibiae, two femora, a left ilium, two humeri and one ulna. The disarticulated nature of the infra-cranial remains meant that it was not possible to explore the number of wounds per individual, however Kjellström (2005, 41) estimates that approximately 18% of a minimum of 60 individuals was affected, much lower than the Ridgeway Hill frequency of 67.5%.

Indirect peri-mortem trauma

Complete skeleton 3805, an older adult, had sustained a complete helical fracture to the distal third of the mid-shaft of the left femur (Fig. 3.84). There was no impact site associated with the fracture suggesting that it had been caused by an indirect force. The same bone also had a possible peri-mortem crush fracture on the anterior surface of the left femoral neck (this has not been included in the present statistics) (Fig. 3.85). Considerable force is required to fracture the mid-shaft of the femur, because it is the most heavily mineralised bone in the skeleton (Galloway 1999, 180). In a modern context this type of fracture may be associated with those involving the femoral neck, may involve serious blood loss and is associated with high energy injuries arising from situations such as plane crashes, motor vehicle accidents, car-pedestrian collisions and falls from a great height (Galloway 1999, 180).

The femur, as well as the left lower limb were numbered separately (3807 and 3808 respectively) from the rest of skeleton 3805 during excavation, because they were found slightly disarticulated from each other in the grave (but still in association; see Chapter 4 catalogue entry for skeleton 3805). Given the peri-mortem trauma this may have been because there was significant soft-tissue damage to the left leg which may have been completely or partially detached at the time of burial. Further, the distal end of the femur was not present with this skeleton, nor was it identified amongst the isolated limbs/extremities or disarticulated bones from the grave, despite the fact that it should have been relatively easy to identify because of its peri-mortem fracture margin. Machine damage to this fracture margin is suspected; in other words it probably is present amongst the disarticulated material, but has since been fragmented beyond recognition as a result of mechanical excavation. This interpretation is supported by the fact that the femur with the helical fracture was found at a slightly higher level than the rest of the skeleton, at the top of the deposit, and was therefore more vulnerable to damage.

Other indirect peri-mortem trauma included a left humeral head impaction fracture or head splitting fracture, observed on isolated humerus 3772. This type of fracture may result from severe impact of the head against the glenoid of the scapula when the bone is dislocated posteriorly, as might occur during a fall onto an abducted arm (Galloway 1999, 122). In addition lower limb/extremity 3781 displayed possible indirect trauma involving the

Fig. 3.85 Skeleton 3805, possible trauma to the anterior surface of the left femoral neck

Fig. 3.86 Skeleton 3753, pseudo peri-mortem trauma to the right foot, plantar surfaces of the right metatarsals

lateral surface of the distal right fibula, which had been completely sheared off. The sheared margins were smooth and flat, consistent with peri-mortem trauma, but their colour was 'white', which is more in keeping with post-mortem damage. This bone surface was lying face down in the ground when it was found, and therefore it is perhaps unlikely that the bone had been cut by the mechanical excavator.

Pseudo peri-mortem trauma

Eleven complete skeletons had lesions that shared characteristics with peri-mortem wounds, but which are, on balance, probably not genuine. These had probably occurred post-mortem, in either the recent past or more closely to the time following their deposition in the grave and before the organic matrix of the bones had completely decomposed (see Table 3.48). On six skeletons the lesions were linear, but lacked the sharp, soil stained appearance associated with incisions made with a blade and/or were located in areas that could not have been reached with a blade around the time of death. These were attributed to damage to the bones (probably wet from water) with sharp tools during excavation (for example, see Fig. 3.86).

Five skeletons had vertebrae with areas of crushing and smeared cortical bone, indicative of a green bone response to direct blunt force injuries with a weapon. However, as wounds, none were in

Table 3.48 Summary of infra-cranial skeletons with pseudo peri-mortem trauma

Skeleton	*Lesion type and location*	*Description*	*Interpretation*
3697	Sharp force. LV3, right hand side, superior surface	'U' shaped cleft, 11mm medial to lateral, 3mm anterior to posterior and 3mm deep. Internally has smeared cortical bone and is the same colour as surrounding bone	The characteristics are consistent with peri-mortem trauma, but the location – in the disc space – and lack of other associated trauma are not consistent with an insult received around the time of death. Excavation damage
3753	Sharp force. Left proximal ulna shaft anterior and medial surfaces; Plantar surfaces, proximal ends of 2nd–5th right metatarsals	Ulna: number of linear 'v' shaped incisions with cortical flaking and 'white'/clean appearance; Metatarsals: Series of defects on plantar surfaces	Ulna: could be peri-mortem trauma with tapho nomic overprinting Shipman (1981) or excavation tool marks Metatarsals: location is consistent with peri-mortem wounding to sole of foot, perhaps whilst lying on the ground and kicking out. However, the lesion is clean and white and lacks sharp, clear cut appearance. Suggests excavation damage
3755	Blunt force. TV 9–12, anterior surfaces	Crushing of trabecular bone and smearing /loss of cortical bone	Lesions are not continuous when vertebrae are held in correct anatomical position, so peri-mortem trauma unlikely. Possibly taphonomic deformation caused by slow loading pressure
3763	Blunt force. TV 10 anterior and left lateral surfaces	Crushing of trabecular bone and smearing/loss of cortical bone	Possibly taphonomic deformation caused by slow loading pressure
3764	Blunt force. LV 4 anterior surface	Crushing of trabecular bone and smearing/loss of cortical bone	Taphonomic – slow leading pressure from femur of another skeleton? No involvement of adjacent vertebrae: area coverage too small and precise if it had been caused by a blunt instrument used as a weapon
3775	Sharp force. Right patella	Two sharp cuts on the joint surface	Excavation damage because not in a plausible location for a peri-mortem insult
3789	Blunt force. LV 3–5 anterior surfaces	Crushing	Taphonomic – slow leading pressure from humerus of another skeleton?
3796	Sharp force. Right humeral head, superior and medial aspects	Penetrating, slot lesions with 'u' shaped profiles, roughly rectangular in plan with crushed in cortical bone	Excavation damage because mud is smeared on/into one of the surfaces
3800	Sharp force. Right proximal humeral shaft, right proximal tibia, left distal femur, and left patella joint surface	Linear penetrating lesions	Excavation damage because they lack the sharp appearance of peri-mortem blades and the lesion on the patella is not in a plausible location for a peri-mortem insult
3804	Sharp force. Left tibia anterior proximal mid-shaft surface	Short, sharp, linear lesions	Excavation damage because very short and lack well-defined margins
3811	Blunt force. Left femoral head and right femoral epicondyle	Areas of crushing; smeared cortical bone	Taphonomic alteration because locations would not make sense if they had been peri-mortem

The left image shows the spine in correct anatomical position (note that the lesions do not line up.
The right image shows the spine as it was discovered *in situ*.

Fig. 3.87 Skeleton 3789, pseudo peri-mortem trauma to the lumbar spine. The site photo shows the humerus of another skeleton underlying the lumbar spine (arrowed)

anatomically plausible locations (for example, in the hip and on the front of the spine). In addition, vertebral lesions were either isolated or, where several were involved, the lesions were not continuous with each other when the bones were held in correct anatomical position. These lesion distributions are therefore not consistent with a blunt object striking the body: the area of coverage was either too small and precise, or where several vertebrae were affected could have only occurred when they were slightly disarticulated. Slow loading pressure from overlying soil and activity taking place on top of the grave, applied over a long period of time to the contact between these bones and bones of adjacent skeletons (probably long bones given the linearity of the lesions) is the preferred interpretation (for example, see Fig. 3.87 opposite).

THE DISARTICULATED BONES *by Helen Webb, Angela Boyle and Róisín McCarthy*

The material includes 2374 fragments of human bone recovered from machine-disturbed soil deposit 3681, 433 disturbed bone fragments (3685) that were recovered during initial hand cleaning of the feature and 148 fragments of bone (small finds, 70 in total, from 3685) that could not be definitively assigned to individual skeletons during detailed excavation (see Chapter 2). It should be noted that where fragments of the same bone could be positively matched/reassociated, these were counted as single fragments.

Information on the skeletal elements present, estimated sex and age, and evidence for non-metric traits, pathology and trauma is summarised and tabulated in Appendix 2. The minimum number and most likely number of individuals represented by this material has been considered along with the skulls and articulated skeletons described under 'Number of Individuals' above (see p. 50 and p. 82).

While the results of the analysis are presented in full in Appendix 2. Key observations are as follows:

1) The difference in elements represented between the disarticulated material from context 3681, compared with that from context 3685, is certainly due to the nature of the contexts. In other words, machine-damaged bone 3681 – comprising larger fragments and recognisable long bone fragments – compared with bones disturbed during decomposition of the corpse and hand excavation (context 3685) – comprising predominantly small fragments, with many small bones, particularly of the hands and feet.

2) The presence of numerous fragments belonging to adolescents and young adults is in keeping with the main skeletal assemblage. Likewise, where sex could be estimated, the overwhelming majority of fragments exhibited features consistent with male morphology, also in keeping with the main assemblage.

Fig. 3.88 Disarticulated left femur (context 3681) with osteomyelitis (anterior and posterior views)

3) Several examples of ante-mortem trauma and pathology are present in the assemblage and are an important addition to the examples identified amongst the articulated skeletons. In particular, they augment the assemblage-wide prevalence for non-specific bone inflammation and infection, *cribra orbitalia* and healed fractures. They also increase the range of pathological conditions identified; for example, a confirmed case of osteomyelitis (Fig. 3.88) and kidney/bladder/gall stones (Figure 3.89) which were not identified amongst the articulated skeletons.

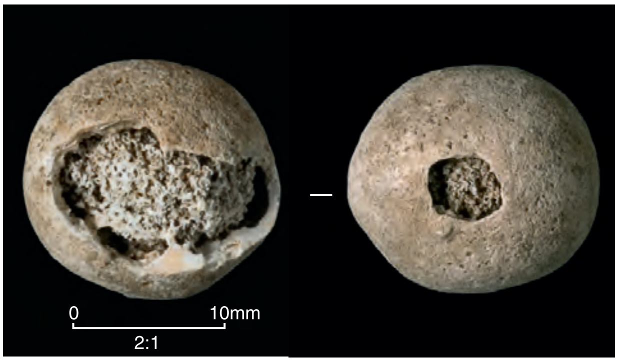


Fig. 3.89 Small find 10384, probable kidney or bladder stone

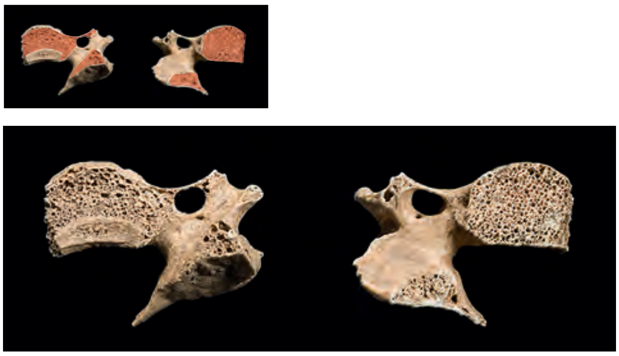


Fig. 3.90 Disarticulated bone, context 3681, peri-mortem sharp-force trauma to a cervical vertebra (superior and inferior views)

4) Patterns of peri-mortem trauma (eg, see Figs 3.90 and 3.91) are consistent with those observed on the articulated remains. Included in the disarticulated bone is the only example in the entire assemblage of a sharp force injury to a maxilla.

5) The only skeletal elements exhibiting peri-mortem trauma were those of the skull, mandible, neck and shoulder regions, in keeping with the peri-mortem trauma observed in the main skeletal assemblage. However, sharp-force trauma to the maxilla bone was not identified in the main assemblage.

6) The vast majority of disarticulated skeletal material probably comes from individuals that have already been accounted for in the main skeletal assemblage. If the disarticulated material comprises skeletons that have not been accounted for in the main skeletal assemblage (that is, additional skeletons) there is nothing to suggest that these would be atypical for this group (ie, no females, no young children etc.).

STABLE ISOTOPE ANALYSES *by Carolyn Chenery, Angela Lamb, Jane Evans, Hilary Sloane and Carlyn Stewart*

Tooth and bone samples were taken from the skulls and skeletons in order to undertake combined oxygen, strontium, carbon and nitrogen isotope analyses to explore the individual's origins, migratory histories and diets. The work was undertaken at the NERC Isotope Geoscience Laboratory and a detailed report is provided in Appendix 3. The main findings are also summarised here.

The results indicate that this was a disparate group in terms of origin, migration and dietary habits. Many, if not all, of the individuals spent most, possibly all, of their lives outside the British Isles. Isotope evidence suggests they may have lived in places as far afield as Scandinavia, the Baltic

Fig. 3.91 Disarticulated bone, context 3681, peri-mortem sharp-force trauma to a right lateral clavicle (superior view)

States, Belarus and Russia all of which fall within viking reach. This group also appear to have a wide range of individual diets, which were high in animal protein and primarily based on terrestrial food sources with small to moderate additions of marine and freshwater protein. The circumstances that brought these individuals to the Ridgeway Hill area are unknown; however isotope data indicates that at least 38 of them were living outside the British Isles in the years leading up to their deaths.

The key points arising from this study are:

1) The oxygen isotope composition of tooth enamel, representing the childhood place of origin of 31 individuals, is beyond the range of UK values for most individuals and is consistent with an origin in a colder climate or a high altitude region.
(a) For 26 individuals the calculated drinking water oxygen isotope composition is consistent with childhood origins in areas including Arctic and sub-Arctic areas of Scandinavia, northern Iceland, the Baltic States, Belarus and Russia.
(b) Five individuals have oxygen isotope values that are compatible with origins, or spending their childhoods, in exceptionally cold locations either north of the Arctic Circle or central Russia.
(c) Five individuals have oxygen isotope values that are consistent with origins either in the UK, Denmark or southern Norway.

2) The strontium isotope composition of tooth enamel supports the "non local" origin.
(a) For 29 of these individuals the strontium isotope composition demonstrates that they were not raised on the local Chalk (on the Ridgeway) or the London Clay in Weymouth, Britain.
(b) Two other individuals have strontium isotope values which are compatible with origins on the local London Clay around Weymouth, but their values are also compatible with geologic terrains in Denmark and the Baltic states.

3) The range of both strontium and oxygen isotope values shows that this is a group of people that do not have a common geographic origin.

4) The oxygen isotope composition of ribs and femurs for 17 complete skeletons, 23 partial skeletons and 5 isolated limbs and extremities, representing at least 40 individuals, falls outside the expected range of the UK. The calculated drinking water values suggest they spent the 10+ years before their deaths in colder areas that are compatible with documented ground and/or surface water values for a wide range of locations including: Scandinavia, northern Iceland, the Baltic States, Belarus, Russia and Arctic regions.

5) The migration history for 31 individuals, as derived from oxygen isotope data from their ribs and femurs, indicates that:
(a) The majority of individuals are unlikely to have relocated during the 10+ years prior to their deaths.
(b) Six individuals are highly likely to have migrated from an exceptionally cold region to significantly less cold locations. Five of these individuals, including two adolescents, have a similar inferred migration pattern and appear to have spent time together in both locations.

6) The carbon and nitrogen isotope data for the majority of individuals is most similar to a population of 10th – 13th century Christians buried at Björned, N Sweden, which is typical for a mixed high protein diet, based on terrestrial and marine sources.

7) Variations in carbon and nitrogen for dentine, femur and rib suggest that, on the whole, the protein content, and in particularly marine protein, of their diets increased over time.

The isotope data for the individuals from the mass grave on Ridgeway Hill are consistent with being a mixed group of people who originated and/or migrated through the areas known to have been occupied by viking settlements between AD 970 and AD 1025.

OSTEOLOGICAL ANALYSIS OF THE HUMAN SKELETONS: SUMMARY OF RESULTS

by Louise Loe

The skulls and skeletons have been considered separately in this chapter because they were encountered as separate deposits within the grave. This also applies to the disarticulated bones. However, all of this material derives from the same group of individuals who were all deposited at the same time and remained undisturbed until their discovery in 2009. Further, the patterns of trauma, consistency in ages and sexes and overall bone morphology of all three groups of human remains argue strongly for direct association between them. In other words, although commingled, the skulls, skeletons and disarticulated bones all belong with each other. It is therefore prudent to consolidate the osteological findings for skulls, skeletons and disarticulated bones by summarising them here.

Number of individuals

It is perhaps surprising that the total number of individuals cannot be conclusively determined. However, what may at first seem a simple exercise to, quite literally, count the number of skulls and the number of skeletons present, has been greatly complicated by the fragmentation, disarticulation and commingling of the skeletons by the mechanical excavation when the deposit was first discovered. Two methods were employed to estimate the number of individuals and different results were achieved, not only with each method, but also for skulls and skeletons. Minimum number of individuals estimates suggested 48 for skulls and 46 for skeletons. However, MLNI calculations suggested 47 for skulls and 52 for skeletons. The MNI is the most popular method employed by anthropologists to quantify the number of individuals present in an assemblage. However, the MLNI is considered to be a better estimator of the original death assemblage, particularly when the goal is to reconstruct events surrounding the deaths of a group of commingled remains, such as Ridgeway Hill. According to Adams and Konigsberg (2008, 241), MLNI estimates the *original* number of individuals represented by a skeletal assemblage, whereas the MNI only estimates the *recovered* assemblage. Provided there is more than 50% bone recovery, good preservation and at least seven pairs of bones, the MLNI is more accurate and appropriate, and, unlike MNI, gives confidence intervals (ibid.). Thus, with this in mind, it would seem that fewer heads (five fewer, considering that one skull was revealed *in situ* but subsequently went missing) than bodies had been buried in the grave.

No compelling re-association between a skull and a post-cranial skeleton could be made. Perhaps one exception is skull 3736 and skeleton 3806 where a match was suggested by corresponding patterns of articulation and joint disease. Although the age brackets assigned to the skull (26-36 years) and skeleton (40–45 years) did not correspond, this is acceptable, considering the fact that they employ different methods which have their own inherent biases and error margins. The skull had peri-mortem blade wounds on the right frontal bone, mandible and cervical vertebrae, but none were observed on the infra-cranial skeleton. Interestingly, skull 3736 is the only one in the assemblage with teeth that had definitely been modified with incised, horizontal grooves and this is discussed further in Chapter 5. The skeleton was among the tallest in the group (178cm) with a high femoral robusticity index (although not the highest; 12.6) and was among few individuals noted to have strong muscle attachment sites. Ante-mortem fractures involving the left ankle and right foot, and infection, possibly brucellosis in the lower spine were also observed. Assuming that skull 3736 had once belonged with skeleton 3806, these observations contribute a fuller profile on an individual who is unusual for the group in having deliberately modified teeth.

Condition and taphonomy

Overall, bone condition was very good or excellent, permitting substantial observations with regard to the physical anthropology and palaeopathology of the group. A number of bones, particularly skulls, were fragmentary and this has limited some observations, especially those relating to cranio-metrics, ancestry assessment and some physical attributes such as handedness and robusticity. Bone surfaces were generally uneroded and none exhibited any evidence of animal scavenging, in the form of tooth punctures or scores/furrows, or bleaching from sunlight. These factors, in addition to a lack of evidence for ancient disarticulation of post-cranial skeletons, suggests that the individuals were buried more-or-less immediately following their deaths and that the grave did not remain open for very long.

Apart from the disarticulation caused by the mechanical excavator and initial hand cleaning, some small bones, particularly hand and foot bones and vertebrae, had also become disarticulated, probably as a result of piled cadavers decomposing (Duday 2006, 50), but this was not extensive. More specifically, variation in the resilience of ligaments between some articulations in the skeleton compared to others, the effects of gravity, the creation of empty spaces for bones to fall into as soft tissues decayed and the transportation of bones, particularly lighter spongy ones, by body fluids and water precipitation from rain (Boaz and Behrensmeyer 1976; Galloway 1999; Duday 2006), are the main factors that will have influenced the disarticulation of these elements within the deposit. The fragmentation of elements as a result of the peri-mortem sharp force trauma has also contributed.

Demography

The separate demographic analyses of the skulls and skeletons both indicate that all of the individuals were males, some with more certainty than others, reflecting the reliability of available indicators over others. There was also a concordance between the mortality profiles of the two datasets, which suggest that most individuals were young adults or younger when they died, with a few aged over 45 years.

Subtle differences in the two age distributions (for example between the 25–35 and 35–45 age categories) are probably due to the different methods employed, their inherent biases and error margins and the fact that a few skulls and skeletons were arbitrarily assigned to categories, because they

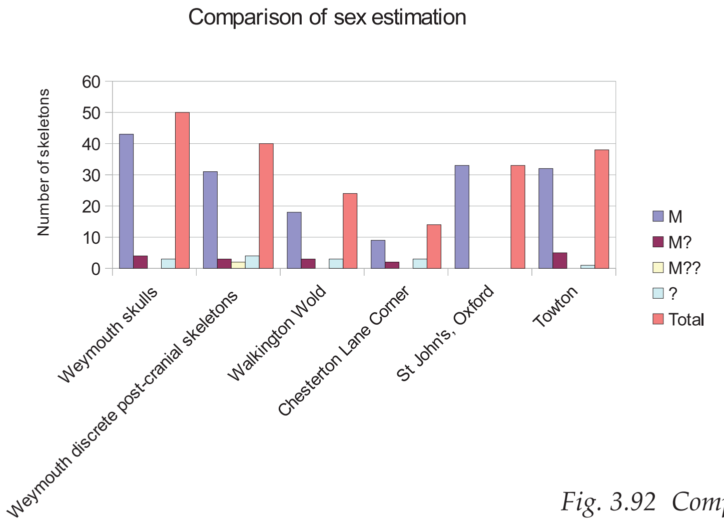


Fig. 3.92 Comparison of sex estimation

fell between two age brackets. In addition, all of the methods employed for the former are known to be less reliable than those for the latter (Cox 2000). This issue was further hampered by the unusual attrition observed on the dentitions to the extent that they were not useful for determining age.

The Ridgeway Hill mortality profiles (not surprisingly) are similar to those of other mass grave contexts, such as Towton and St John's College (Figs 3.92 and 3.93) in having a greater proportion of young adults/ adolescents. Although not directly comparable, because of the ageing methods employed, the mortality data for the skeletons from visby reflect a similar trend: 22% of the individuals were below the age of about 20 years, 14% were above the age of about 35 years and 64% were between the two ages (Ingelmark 1936, 159).

Further comparison between Ridgeway Hill, St John's and Towton shows that only the first two have individuals who were less than 16 years of age, while only Ridgeway Hill and Towton have individuals who were over 45 years of age (Fig 3.93). The mortality peaks for the three groups are also different, being 16–20 years (Ridgeway Hill), 21–25 years (St John's) and 26–35 years (Towton). Both the St John's College and Ridgeway Hill mortality profiles have very similar average ages at death (*c* 25 years and *c* 26 years), which are younger than at Towton (*c* 30 years) and Uppsala, Sweden (*c* 27.7 years). Overall, the Ridgeway Hill mortality profiles would seem to share similarities with those from other mass grave contexts, but they do not resemble,

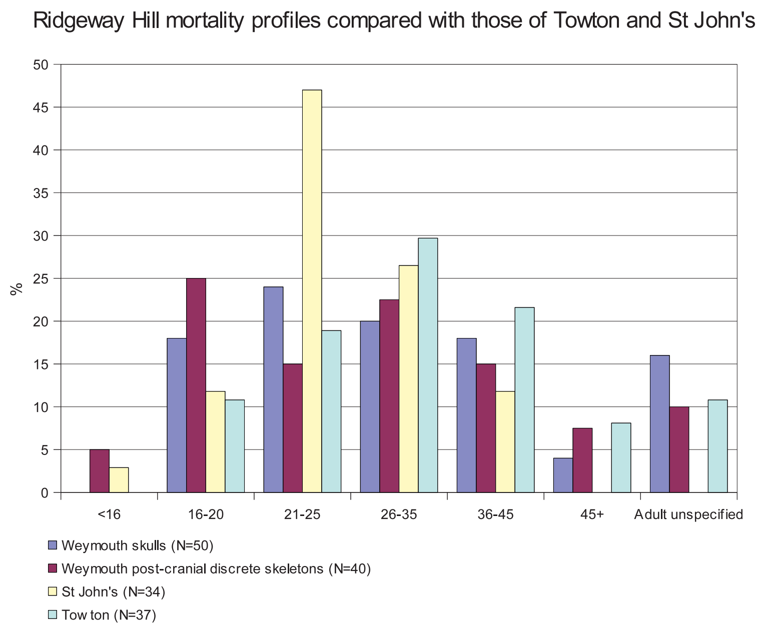


Fig. 3.93 Ridgeway Hill mortality profiles compared with those of Towton and St John's

in this respect, battle related mass graves any more than they do the context from St John's College. Demography is considered further in Chapter 5.

Physical attributes, ante-mortem pathology and trauma

Only one skull survived sufficiently intact for ancestral traits and cranial indices to be explored; these most closely resembled those of Viking Age Denmark. This result was also reflected in the estimated mean stature for the group, although the standard deviation was large (*c* 5cm). Handedness and robusticity were explored, but the results were limited and inconclusive, although generally speaking some individuals were judged to be robust, based on the appearance of muscle sites and metrical assessment.

The dentitions were notable for their abnormal patterns of attrition, inconsistent with typical age related wear patterns that have been observed archaeologically (eg, Brothwell 1981; Miles 1962). It is not clear what had caused this, but food preparation techniques, the kinds of food eaten, mastication behaviour (food preparation and eating) and variation in crown morphology are among the possibilities (Larsen 1997). One individual had deliberately modified teeth, in the form of incised horizontal grooves and other possible examples of dental modification were also identified. Parallels for this activity have been observed on Viking Age male skeletons from Sweden and Denmark, possibly as a mark of occupation, or personal adornment (Arcini 2005). Dental modification is discussed further in Chapter 5.

A range of dental conditions was observed, peri-mortem trauma associated with decapitation being the most prevalent, followed by periodontitis. Other conditions, namely calculus, caries, ante-mortem tooth loss and dental enamel hypoplasia were relatively infrequent.

Skeletal pathology observed among the group was characterised by non-specific bone inflammation resulting from systemic disease; infection and conditions (for example, Schmorl's nodes, *osteochondritis dissecans* and *os acromiale*) that are associated with mechanical stress from a young age. This includes one spectacular example of bone infection ('osteomyelitis'). Conversely, metabolic conditions, such as iron deficiency anaemia, and joint disease were infrequent. Ante-mortem trauma, in the form of healed and healing fractures and muscle trauma were present but they were not particularly prevalent. However, a couple of these – an un-united clavicle fracture and a femur shaft fracture – were notable for the physical impairment they are likely to have caused to mobility in life.

Peri-mortem trauma

Peri-mortem trauma was observed on a total of 44 skulls (88%, 44/50) and/or teeth and/or associated cervical vertebrae, 27 (67.5%, 27/40) discrete infracranial skeletons and three isolated limbs/extremities. Virtually all of the lesions were sharp force injuries that primarily involved, in order of most to least frequent, the neck, skull and shoulder girdle and were associated with decapitation. A comparatively small number of sharp force lesions, not directly associated with decapitation, were observed on crania and bones of the forearms and hands. The lesions ranged in extent from superficial cuts to, most often, completely penetrating chops, delivered from a variety of directions, although those to neck regions (skulls and vertebrae) were more commonly from behind. Besides sharp force trauma, indirect trauma was observed on the femur of one discrete skeleton and on two isolated bones, a humerus and fibula. The peri-mortem trauma observed amongst the disarticulated, machine disturbed, bones, was consistent with the patterns observed amongst the skulls and discrete skeletons. That is, sharp force lesions focussed on the neck region with some involvement of hand bones.

The timing of the decapitations is important to consider, because depending on whether they occurred at the point of death, or immediately in the post-mortem interval, the implications are different. Examples of both have been observed archaeologically, including those performed following death in relation to funerary rite, as has been discussed for Roman populations (Philpott 1991); or at the point of death in relation to corporal punishment, as has been observed for a number of individuals of Anglo Saxon date (Reynolds 2009; see Chapter 1). They may also be associated with post-mortem dismemberment, as has been interpreted for several prehistoric contexts (for example, Carr and Knüsel 1997). Smith and Brickley (2004) concluded that a clavicle from the Neolithic chambered tomb of West Tump, Gloucestershire, had been modified by post-mortem decapitation for reasons relating to funerary practice, based on the location of cut marks on the bone; the decapitation could not have been performed unless the clavicle had been free / disassociated from the corpse (Smith and Brickley 2004).

However, timing is not always possible to detect in the archaeological record. According to Boylston *et al*. (2000, 248) chops involving the posterior aspects of the vertebrae, delivered from a posterior to anterior direction, and chops delivered from one side of the neck and with associated weapon trauma, especially defence injuries, are consistent with decapitation at the point of death (the former in association with execution and the latter, combat related trauma). On the other hand, Armit *et al*. (2011, 273), discussing neck posture in decapitation, note that lesions involving the occipital bone at the back of the skull and suggestive of decapitation with the head held in extension (that is, the neck extended forming an acute angle with the back), would be the same whether the individual was living or recently deceased. The lesions observed on the Ridgeway skeletons are difficult to interpret in this respect because, although they reflected a tendency to be delivered from the posterior, this trend was not overwhelming and blows from the anterior to posterior and the sides were also observed. However, overall the high frequency of heavy cuts delivered to the region of the neck, suggestive of assaults delivered with some considerable force, combined with evidence for bladed trauma involving other parts of the skeleton and suggestive of incapacitating and defence injuries, argue in favour of decapitations at the time of death.

It is difficult to estimate the *actual* number of wounds observed, because of the separation of skulls with some vertebrae (or parts of some vertebrae) from skeletons, coupled with bone loss and fragmentation caused by the trauma. Thus, neck vertebrae, present with skulls and skeletons, were often partial and could not be reconstructed into discrete spines. Analysis has therefore treated vertebrae recovered with skulls separately from vertebrae recovered with skeletons and this will have inevitably resulted in counting wounds more than once (for example, where one wound may have involved more than one vertebra), or not at all. In addition, numbers do not take into account the disarticulated material, which also contained examples of peri-mortem trauma. While it may be possible to more accurately determine the number of wounds by detailed matching exercises, or by employing the zonation methodology described by Knüsel and Outram (2004), this was beyond the scope of the present project (although all cervical vertebrae have been scored by zone on records, held in the archive). With these points in mind, it is tentatively suggested that approximately 188 wounds were observed in the entire assemblage, giving a total average number of 3.6 wounds per individual (188 divided by the most likely number of individuals: 52). Further, sharp force trauma was present on approximately 3.3% of all cervical vertebrae (101 wounded vertebrae associated with skulls and skeletons combined, out of a total of 264 complete and incomplete vertebrae found with skulls and skeletons), suggesting an average number of almost two neck wounds per individual (101/52 individuals).

Further details pertaining to the peri-mortem trauma are discussed in Chapter 5 where a fuller discussion of the osteology is also presented, with reference to the archaeological context and other archaeological comparanda.