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BRITISH ASSOCIATION FOR BIOLOGICAL ANTHROPOLOGY AND OSTEOARCHAEOLOGY

Updated Guidelines to the Standards for Recording Human Remains

Editors: Piers D Mitchell and Megan Brickley

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Front cover image Excavation of human burials from a medieval Augustinian friary in Cambridge. Image courtesy of the Cambridge Archaeological Unit.

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Piers teaches palaeopathology in the Department of Archaeology and Anthropology at the University of Cambridge. He has trained in medicine, archaeology, medical history, and education. Piers has a strong research interest in ancient infectious diseases, especially parasites. He has been President of BABAO (2012–2015) and President of the Paleopathology Association, the worldwide organisation for the study of disease in the past (2015–2017). Piers has published six books, including *Sanitation, Latrines and Intestinal Parasites in Past Populations* (2015, Routledge). He is also editor-in-chief of the book series *Cambridge Texts in Human Bioarchaeology and Osteoarchaeology* (Cambridge University Press).

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Linda is a qualified medical doctor, specialising in forensic and biological anthropology. Together with Prof. Margaret Cox, she helped establish and direct Bournemouth University's internationally acclaimed postgraduate provision in Forensic Archaeology and Anthropology. Consultancy incorporates reporting from archaeological sites, as well as assisting the police and related professionals with individuals recovered from forensic contexts. In 2009, she was employed by Oxford Archaeology on the Fromelles Project and has since become a visiting lecturer at Reading University and a member of the Blake Emergency Services International Response Team. She also works for Silva Legal Services as a Medical Record Analyst in clinical negligence cases.

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Martin is Principal Academic in the Department of Archaeology, Anthropology and Forensic Science at Bournemouth University. He has particular interests in taphonomic changes and injuries to the skeleton. Martin has worked on a broad range of prehistoric material but has worked most extensively on collective burials from the Early Neolithic. He is co-author of *People of the Long Barrows: Life, Death and Burial in the Earlier Neolithic* (2009) and co-editor of the *Routledge Handbook of the Bioarchaeology of Human Conflict* (2013). Martin has published papers ranging from vertebrate scavenging, ballistic injuries, mummified remains and ethical issues surrounding human skeletal remains.

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Sonia obtained her PhD in Biological Anthropology at the University of Cambridge, and is now an Associate Professor of Archaeology at the University of Southampton, focusing on bioarchaeology. Her main research interests are in morphological population variation in relation to aspects of human identity, including migration, religion, disability and race within a variety of regions, including Egypt, the Caribbean and Britain. She has also looked at changes in social identity and its identification through other aspects of bioarchaeology, such as sexual dimorphism or changes in activity patterning, and has linked these through funerary archaeology and artistic representation with the wider burial record. From 2014 to 2017 she was Vice-President of the Paleopathology Association.

1 Introduction

Piers D Mitchell, Megan Brickley

In 2004 the British Association for Biological Anthropology and Osteoarchaeology (BABAO) published the first edition of *Guidelines to the Standards for Recording Human Remains* in the Institute for Field Archaeologists publication series. It was edited by Megan Brickley and Jacqueline McKinley, and its aim was to provide a guidance document to give specialists in osteoarchaeology and burial archaeology a framework within which to work while maintaining a high level of professionalism. It was primarily aimed at those engaged in recording human skeletal remains from commercial excavation projects, so ensuring standardised recording and greater comparability between the reports of human bone assemblages from different sites. The 2004 guidelines followed on from guidance on assessment and analytical reports on human remains produced in 2002 and reprinted in 2004 (Mays et al 2004).

Since that time these guidelines have supported those working in the field and when compiling skeletal reports for their clients, as well as being of great use to researchers in an academic environment and to museum curators. They have assisted practitioners to ensure their professional activities meet the BABAO *Code of Ethics* and *Code of Practice*. The guidelines also ensure practitioners can meet Principles 3 and 4 of the CIfA *Code of Conduct* (CIfA, 2014) regarding the quality of their work, and the various standards and guidance documents published by CIfA (http://www.archaeologists.net/codes/cifa). Having guidelines that specify what should be included in a skeletal report helps to ensure that sufficient time and funding is allocated by clients engaging the services of a commercial archaeological service.

It should be understood that those osteoarchaeologists in commercial units might not have the funding available to organise some of the more expensive analyses such as ancient DNA, isotopes or radiological imaging. However, what is important is that all involved are aware when such analysis can be helpful, and when samples could be stored for analysis at a later date.

The authors of the 2004 guidelines anticipated that the document would probably have a lifespan of ten to fifteen years (Brickley 2004), and they were correct. Over the last 14 years there have been advances in research methodology that have necessitated an update to this volume. Following consultation with the BABAO membership, it was decided to create updates for each chapter that focus on those advances published since 2004, together with changes in ideas and approaches over this time. Due to work commitments Jacqueline McKinley was not able to act as editor on this update, so her role has been taken over by Piers Mitchell. It is fitting that the update should be published once again by the (renamed) Chartered Institute for Archaeologists (CIfA). This is, in effect, a refresher on all that is cutting edge in the field.

An additional chapter has been added on the topic of sampling human burials for the eggs of parasitic worms that caused gastrointestinal infection when the individual was alive. This type of analysis has become a more common practice than was the case ten or twenty years ago.

The volume has passed through an intensive peer review process. Every chapter has been reviewed by at least 15 experts, some based in Britain and others internationally. This will ensure that the views expressed in the guidelines represent a broad spectrum of opinions in the field.

This guidance is primarily targeted towards the needs of osteoarchaeologists in Britain, but we also envisage it being of use to those excavating and analysing human skeletal remains across the world.

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2 Compiling a skeletal inventory: articulated inhumed bone

Megan Brickley

First questions to be asked of any assemblage of human bone will be: how many individuals are present and how well preserved is the skeletal material?

With most assemblages, a minimum level of recording of numbers of individuals and levels of preservation set out in Mays et al (2004) should have been undertaken at the assessment stage. However, for the production of a human bone report the exact number of individuals present should be calculated, and the condition of the bone of each individual should be analysed and recorded.

2.1 Completeness

There are many systems for recording the completeness of a skeleton, for example those outlined in Buikstra and Ubelaker (1994). The system selected will largely depend on the specific research questions to be addressed but, as a minimum, numbers of each bone type and all major joint surfaces should be recorded in such a way as to allow prevalence of pathological conditions to be calculated (see Chapter 11). A clear reference should be provided for any system used to describe the completeness of a skeleton (or the full methodology employed set out in the case of unpublished techniques). Use of visual recording forms such as those included as appendices of the 2004 version of this document will allow not only the completeness but also the amount of fragmentation to be recorded.

2.2 Fragmentation

Fragmentation has important implications for the amount of metric data that can be recorded. Systems of recording should be made clear and should be fully referenced, if applicable, in the final report. In the case of highly fragmented skeletons, refer to Chapter 5 for aspects of fragmented bone that should be considered. Recording features such as abrasion/erosion and the characteristics of broken ends may assist in determining the cause of fragmentation in articulated skeletons.

2.3 Surface preparation

Previously it was recommended that Behrensmeyer (1978) was used to record surface preservation, but human bone weathers differently to animal bone (which tends to have a much denser cortex) and the varied burial environments encountered within contexts across the British Isles result in different mechanisms acting on the bone. The surface preservation of bone should be recorded following published guidelines, and the system set out by McKinley (2004) is recommended, since statements such as 'the bone was well preserved' are almost meaningless unless they have been clearly defined, as there will be discrepancies in the way different researchers apply and interpret such a statement. Information on the surface preservation of bone is important for interpretations of the prevalence of many pathological changes in bone, for example periosteal new bone formation.

2.4 Exclusion of skeletons with less than ideal preservation

Recent work has demonstrated that human skeletal remains may be partial and poorly preserved due to underlying pathological processes (eg, see Brickley and Buckberry 2015). Those undertaking recording of human remains should consider that exclusion of less well-preserved skeletons may lead to the loss of significant information on pathological conditions that result in loss of bone density and structure (eg, age-related bone loss, deficiency of vitamin C and D, and neoplastic conditions). Individuals buried at earlier dates may be more likely to be disturbed in some settings and stratigraphic data should be carefully considered before decisions on recording are made. Results from investigations that exclude poorly preserved remains will be biased. Recording using true prevalence rates as recommended by Mays et al (2004) will allow missing elements to be accounted for during data analysis.

2.5 Recording sheets and archiving

The use of paper or electronic means for recording skeletal completeness, or a combination of these two media, will depend largely on the circumstances of the individual undertaking the recording. However, the durability of records and their accessibility to future researchers should be carefully considered; rapid computer development has rendered many programmes and operating systems obsolete in recent years. Any system used should allow information on the bones present to be accurately recorded in a format that will allow reporting of the true prevalence of pathological and traumatic lesions, and differentiation between undetermined and ambiguous individuals in evaluation of sex and ancestry (see appropriate chapters of this volume). Generating backups and having 'disaster management' plans for digital data should be part of the process of setting up any digital recording system.

Records should be prepared in line with current standards and guidance on the archiving of paper and digital data (Brown 2007 http://www.archaeologists.net/sites/default/files/ifa_practice_archives.pdf). Where work is to be deposited in a regional archive, records should also be prepared to local, documented standards.

Archiving reports that fall within the grey literature with the Archaeology Data Service (ADS) is considered best practice.

A number of recording sheets depicting complete skeletons and individual bones are presented in Buikstra and Ubelaker (1994). Whilst some of these are useful and enable detailed recording of individual elements and features observed on bones, the complete skeleton sheets (both adult and juvenile) are felt to lack the detail useful as a means of recording. An updated set of recording sheets is provided in the appendix of this document (Appendices 1–3), for those wishing to record greater detail. Additional forms for perinatal, early childhood and late childhood cranial bones and skeletal completeness are provided in Chapter 9 of Schaefer et al (2009).

2.6 Visual recording (illustrations)

Various means of visual recording are available: photographs, radiographs, professional drawings and sketches. It is recommended that as many visual records as possible are obtained during the recording of skeletal and dental material, although the purpose of such recording, to assist in diagnosis or illustrate a point, should always be kept in mind.

Clearly, the extent of this type of recording will depend on factors such as the nature of the assemblage and the research questions posed. However, such recording should be considered a vital part of any project (especially primary recording of skeletal material on a commercial basis). Costings for adequate recording of this nature should always be made whether the project is research or commercially funded. As a minimum, photographs of publishable quality should be obtained for any item discussed in the report produced. Although drawings and photographs produced by professionals are indispensable for final reports, the value of images made by the person undertaking the recording should not be underestimated and photographs of the complete skeleton and individual elements for further reference during the writing of a report can be very valuable. Illustrations form a particularly important part of the archive where skeletal material is to be reburied.

Photographs should always be viewed in the format they are to be produced in before being submitted for publication. For example, some of the detail visible on a colour picture may be far less clear if reproduced in black and white. Monochrome photographs are often more appropriate than colour images to illustrate fine surface details, such as cut-marks, abrasions or surface etching. Colour images may, however, illustrate some pathological lesions better than a monochrome image.

The possibility of obtaining images from microscopic examination should also be considered. In many instances it may be possible to observe and record the features of interest using light or digital microscopy, and many microscopes have camera attachments or digital recording features. Basic digital microscopes are now priced such that they will be accessible to many organisations. At the assessment stage of a project the possibility that microscopic examination of material may be required should be considered. Early planning will allow funds to be requested and/or suitable equipment to be located prior to the start of recording.

Useful information on procedures for obtaining various types of visual record are contained in Buikstra and Ubelaker (1994, 10–14), Bruwelheide et al (2001) and White (2000, 517–518). However, the quantity of images – particularly radiographic –

required will normally be less as these guidelines assume that material will be reburied after primary analysis and this is not normal practice with British archaeological material.

Additional information on visual recording of various types can be found in Williams (2001). Full visual recording will enhance both the quality of the report or paper published, and form a valuable resource in the archive. The need for long-term accessibility and practicalities of archiving visual records of various types should be considered at the planning stages of any project.

Long-term archiving of visual records should be considered; as set out in Section 2.5, plans should be made at the start of a project.

2.7 3D laser scanning

Recent projects, such as *Digitised Diseases*, run from the Biological Anthropology Research Centre, University of Bradford, show the ways in which technological developments allow the recoding of detailed information on pathological and taphonomic changes to bone. Digital archives such as that created as part of the *Digitised Diseases* project also allow widespread access to material without causing further damage that comes from handling bone. http://www.digitiseddiseases.org/alpha/.

Technologies such as 3D printing of scanned items are developing rapidly. At present the quality of prints is not sufficient to accurately record pathological and taphonomic change, but this is likely to change in the future.

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3 Recording and analysing the human dentition

Daniel Antoine

Subtle morphological variations can be used to identify and side individual teeth (see Hillson 1996, 14–67; Lease 2016). The human dentition is usually comprised of 20 deciduous (or milk) teeth that are gradually replaced with 32 permanent teeth. The permanent dentition starts to form just before birth and ends with the development and eruption of the third molars in the late teens to early twenties. During long periods of a child's life, both deciduous and permanent teeth are present in various states of development (see Hillson 1996 for recording dental development). The number of teeth in an adult dentition can occasionally vary. In some, teeth such as the third permanent molars can be congenitally absent. Disease, trauma or cultural practices may also lead to the loss of teeth during life, whilst some are lost post-mortem. Extra (supernumerary) teeth are less common and usually have a highly irregular form (Nelson 2016). Although most of the methods employed to identify and label teeth have remained the same since the last edition, many of the approaches used to analyse and interpret the human dentition and its supporting alveolar bone have been re-evaluated and improved upon (eg, Irish and Scott 2016).

3.1 Inventories

Dental inventories are used to record the presence of individual teeth. As teeth can be lost pre- or post-mortem, the presence of their supporting structures (ie, tooth positions or the root sockets into which they may have once fitted) should also be recorded when observable. Most systems divide teeth into four quadrants that mirror each other: the maxillary right, maxillary left, mandibular left and mandibular right (see van Beek 1983, 3–6; Hillson 1996, 6–12). The upper and lower quadrants are divided into left and right by an imaginary line that passes between the central incisors. When all teeth are present and developed, each quadrant of the permanent dentition is made up of two incisors, one canine, two premolars and three molars. Many recording systems number the teeth in each quadrant from one to eight respectively from the central incisor to the third molar. In the deciduous dentition, each quadrant is made up of two incisors, one canine and two molars labelled from 'a' to 'e' or 1 to 5 respectively from the central incisor to the second molar.

3.2 Labelling systems

Most labelling systems make use of these numbers or letters to avoid using lengthy tooth names. Quadrants are simply identified by adding 'U' for upper or 'L' for lower, with 'L' and 'R' used to distinguish left and right. Hence, 'UR3' would represent the upper right permanent canine and 'LLd' (or 'dec. LL4') used to denote the lower left first deciduous molar. Alternatively, teeth can be identified by their initials, with 'I1' and 'I2' for the central and lateral incisors, 'C' for the canine, 'P1' and 'P2' for the first and second premolars (also labelled 'P3' and 'P4' in some evolutionary systems), and 'M1', 'M2' and 'M3' for the first, second and third molars respectively (eg, 'ULP2' represents the upper left second premolar and 'dec. LRC' the deciduous lower right canine). This system is used in most publications (eg, *American Journal of Physical Anthropology*; Hillson 2014; Irish and Scott 2016). Many variants exist and, as with all recording methods, great care should be taken to note the labelling system used. Permanent and deciduous teeth should also be clearly distinguished, particularly when numbers (and not letters) are used to identify the deciduous teeth.

The Zsigmondy system (van Beek 1983, 5; Hillson 1996, 8–9) provides a shorthand alternative that is particularly useful when labelling bags. As above, the teeth of each quadrant are identified using the 1–8 numbering for the permanent dentition and a–e lettering for the deciduous teeth. Quadrants are simply identified by framing the number or letter with a vertical and horizontal bar. If the number or letter is below the horizontal bar, it is a lower tooth, and when above it, an upper tooth. As the dental arcade is being observed head-on in the correct anatomical position, if the vertical bar is to the right, it is a right tooth and vice versa. An upper right permanent canine would be labelled: 3|

These labelling systems cannot be inserted into a database and the FDI (Fédération Dentaire International) system provides the most suitable computer-friendly labelling method. Here, the first number denotes the quadrant (numbered clockwise from the upper right) and the second number identifies the tooth (as above, 1–8 for permanent and 1–5 for deciduous). For example, 16 represents the upper right first permanent molar and 62 the upper left deciduous lateral incisor. As with the Zsigmondy system, the viewer is observing the body facing the skull, with left and right reversed from the viewer's point of view:

Upper right permanent								Upper left permanent							
18	17	16	15	14	13	12	11	21	22	23	24	25	26	27	28
48	47	46	45	44	43	42	41	31	32	33	34	35	36	37	38
Lower right permanent								Lower left permanent							

Upper right deciduous					Upper left deciduous				
55	54	53	52	51	61	62	63	64	65
85	84	83	82	81	71	72	73	74	75
Lower right deciduous					Lower left deciduous				

The FDI system allows each tooth to have an easily determined and unique number, making it possible to calculate tooth-specific prevalence rates. Alternatively, Buikstra and Ubelaker's (1994) numbering system labels the permanent dentition from 1 to 32 and the deciduous dentition from 51 to 70.

Recording the presence or absence of individual teeth does not usually suffice, as teeth are often absent or non-recordable for a number of reasons. Forms should ideally differentiate between ante- and post-mortem loss, and record the number and position of all observable teeth. The simplest recording forms strike through the tooth to indicate post-mortem loss. Buikstra and Ubelaker (1994, 47–49) recommend the following codes: 1: 'Present, but not in occlusion'; 2: 'Present, development complete, in occlusion'; 3: 'Missing, with no associated alveolar bone'; 4: 'Missing, with alveolus resorbing or fully resorbed: pre-mortem loss'; 5: 'Missing, with no alveolar resorption: post-mortem loss'; 6: 'Missing, congenital absence'; 7: 'Present, damage renders measurement impossible, but other observations are recorded'; 8: 'Present, but unobservable (eg, deciduous or permanent tooth in crypt)'. Codes 3–6 can be used to calculate the prevalence of ante-mortem tooth loss as long the codes are interpreted in a manner that allows for such calculations (eg, code 3 should be equivalent to 'no data'). The presence of the supporting alveolar bone is, however, often recorded separately by tooth position (or the root sockets into which they once fitted) in order to determine the prevalence of periapical cavities (see below).

3.3 Dental disease

When appropriate, dental disease (see Hillson 2005, 286–318; Hillson 2008b; Nelson 2016), dental measurements (see Hillson 1996; 2005) and, should time allow, morphological crown and root traits (see Scott, Maier and Heim 2016) should be recorded. Buikstra and Ubelaker's code 7 (above) raises a very important point; poor preservation, as well as advanced dental wear, can affect some observations. Calculating the prevalence of any pathological changes (eg, hypoplasia, caries) should take preservation (ie, how complete teeth are) and wear into account (see methods for recording wear in Hillson 1996; Burnett 2016) as these have an impact on the surfaces observed (Hillson 2001). Individuals with highly worn crowns, for example, are unlikely to show signs of occlusal surface caries and most hypoplastic defects are no longer visible if the enamel surface is worn (eg, via brushing or cleaning), absent (ie, attritional wear) or covered by calculus. Overzealous post-excavation cleaning can also damage the enamel surface or remove dental calculus, which has become a valuable source of biomolecular information (eg, Warinner et al 2014; for recording calculus see Hillson 1996, 255–260; Hillson 2008b). With regard to hypoplasia, the degree of magnification is also likely to have a major impact on the number of defects observed and one may question whether it is possible to record these in a way that allows for comparisons between populations (see detailed review in Hillson 2014).

The prevalence of dental pathology should not be calculated by aggregating all teeth within an assemblage but should – as a minimum – be divided by tooth type or class and, where possible, be subdivided into wear groups to account for different wear patterns between assemblages. Summaries that report the total number of teeth affected within a population unfortunately combine tooth classes with differing wear patterns and susceptibilities to disease. This is particularly problematic for caries, with the deep fissures and crevices present in posterior teeth, particularly molars, making them more susceptible to tooth decay (see discussion in Temple 2016). To provide greater specificity and generate comparable prevalence data, tooth decay should – time permitting – ideally be recorded by tooth surface and take into account morphological differences between tooth classes (see Hillson 2001; 2008a; 2008b). When all teeth are grouped together and tooth decay is presented as a summary of total tooth count, assemblages with higher numbers of posterior teeth are likely to be biased when compared to samples with higher numbers of anterior teeth, or differing wear patterns. Without considering these factors, differences in dental disease prevalence may simply reflect tooth-class preservation bias or variations in ante-mortem tooth loss, age distribution, patterns of dental wear or tooth-surface preservation. Though time consuming, recording carious lesions by tooth surface (eg, the number of occlusal surface caries in lower first molars with an observable occlusal fissure system) allows such differences to be taken into account when comparing assemblages.

The bone supporting teeth should also be carefully scored for periodontal disease (see Hillson 1996, 260–269; Kerr 1988), which is often linked to root exposure, root surface caries and ante-mortem tooth loss (Nelson 2016). The presence of periapical cavities or voids should also be recorded but, as they do not always involve an externally visible sinus, their prevalence can be hard to establish. All root sockets should be examined by carefully lifting the teeth out (something that is not always possible) or by using radiographs to image the root apices (should time and finances allow). Their location and size, as well as the appearance of the cavity wall and (when present) sinus margins, should be carefully documented and used to distinguish abscesses from granulomas and cysts (Figure 3.1) (see Hillson 2008b; Ogden 2008; Nelson 2016).

Figure 3.1 Upper right first molar destroyed by tooth decay, with a periapical cavity in the underlying bone. The roughened appearance of the periapical cavity wall indicates an ongoing infection and identifies it as an abscess (rather than a smooth-walled granuloma or cyst). Skull from site 3-J-23, Grave 7, 4th Nile Cataract, Sudan. Medieval period, 4th–15th century AD. Image by R. Whiting, courtesy of the Trustees of The British Museum

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4 Compiling a skeletal inventory: cremated human bone

Jacqueline I McKinley

Since the 2004 edition of this volume there has been a marked increase of interest in cremated bone and the mortuary rite of cremation in the UK. This has led to the publication of several volumes of work dedicated to cremated/burnt human remains, their context and/or the mortuary rite (eg, Artelius and Svanbery 2005; Davies and Mates 2005; Schmidt and Symes 2008; 2015; Thompson 2015a), adding to the small number of existing volumes of this nature (eg, Holck 1986; Lange et al 1987; McKinley 1994a; Sigvallius 1994; Smits et al 1997). There has, in addition, been a growing frequency of contributions on the subject included in more holistic publications on mortuary studies (eg, Tarlow and Nilsson Stutz 2013).

The basic aims of the osteological analysis remain much the same as they have been in the past. Technological advancement and increased accessibility to specialist equipment have led to new techniques being applied to cremated bone. This has broadened the scope of study and had some radical effects on our understanding of the use of the mortuary rite in antiquity.

Whilst the specialist aims to recover the basic osteological data pertaining to the cremated individual, they also seek to recover information relevant to the technological aspects and rites of cremation. The systematic recording of data from individual cremation-related deposits enables subsequent analysis to detect variations and similarities in the rite, which may be influenced by the age or sex of the individual, or cultural, temporal or geographic factors. The ancient mortuary rite of cremation was a complex and multi-faceted mode of disposal of the dead. It had the potential to create a variety of deposit and feature types for which we may recover archaeological evidence (eg, McKinley 2013). Consequently, analysis of the cremated remains by an osteologist is inextricably linked with the context of origin. The form and nature of the archaeological deposit will affect the condition of the cremated bone and both data sets (collected in the field and the laboratory) are vital in interpretation of the type of deposit represented. A range of cremation-related features and deposits is commonly encountered in close association as part of the 'mortuary landscape', but the 'transportable' nature of cremated remains means that some deposits are, and others potentially may be, found outside this arena (Eriksson 2005; McKinley 1994b, 70–71; 2006; Metcalf and Huntington 1991, 102; Oestigaard 1999; van Gennep 1977, 152).

Analysis of cremated remains also requires an understanding of the cremation process. Modern crematoria offer the most effective and efficient environment in which cremation is undertaken, but it is also important to consider those factors which may have influenced the equally sophisticated but potentially less controllable environment of an open pyre in the past, including accidental or deliberate curtailing of the process/cooling of the pyre, and secondary (ie, post-cremation) rites (DeHaan 2008; McKinley 1994a, 72–76; 2016, 19–26; Symes et al 2008; Thompson 2015b; Walker et al 2008). For an overview of the weights of bone recovered by various workers from modern crematoria see Gonçalves 2012; Gonçalves et al 2013.

4.1 Recording

For those working with cremated remains for the first time (and even thereafter), it is advisable to have a full skeleton accessible for comparative purposes. Correct identification of the skeletal element represented by small, heat-altered fragments can be difficult and it is always wise to check to avoid mis-identification that may contribute to subsequent misinterpretation. Section 4.3 in the 2004 edition presented the four categories of 'identifiable' bone; within these categories individual elements should be recorded as closely as possible, such as 'right nasal process', 'left petrous temporal (anterior portion)', 'proximal foot phalanx head and shaft', together with data pertaining to age/sex/pathological lesions and unusual fragmentation or colouring (outside the white of full oxidation).

The occasional use of radiographs and computerised tomography (CT) scans for the initial examination of the remains of urned cremation burials (lifted *en masse* from site for laboratory excavation) prior to excavation of the remains has been undertaken for some years (eg, Anderson and Fell 1995). CT scans are of greater assistance than plain film radiographs, although ready and frequent access to the necessary expensive equipment is likely to be severely limited for many osteologists, especially in the commercial sector; often one has to engage with an accommodating hospital department which may be happy to undertake small numbers of urns but which may balk at several dozen. It should be recognised that CT scanners in National Health Service premises are naturally prioritised for patients. There are times when this technique can be of particular assistance, most pertinently where the soil acidity (eg, in the case of clay, silty clays, siliceous sands, peat) can cause destruction of much of the trabecular bone; the latter will be apparent in the CT scan and visible during excavation but would crumble to dust on excavation (eg, Harvig 2015). Elsewhere, such as when an unusual vessel was used as the container for burial, a CT scan will give a view of the contents to assist with recording in excavation (Figure 4.1). Such images alone cannot, however, provide answers to all the aims of analysis.

A

B

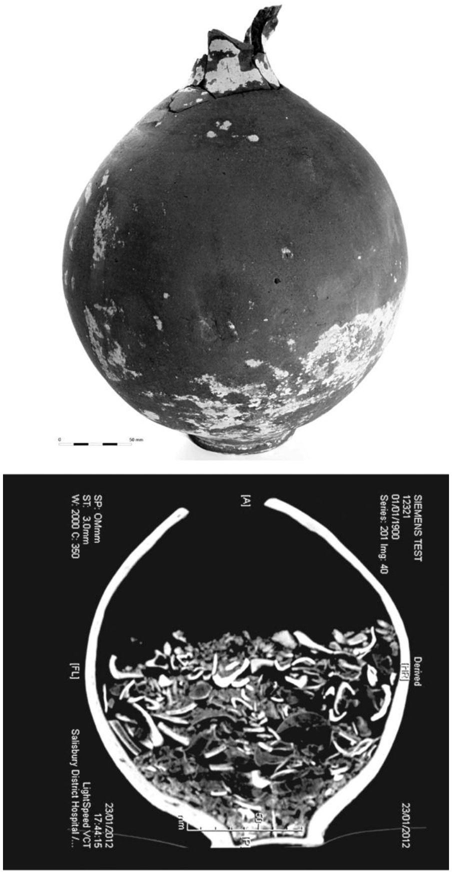

Figure 4.1 Remains of urned cremation burial from Grave 42001, East Kent Access Road: A) vessel showing broken neck through which bone was inserted into vessel, B) computer tomography (CT) scan of vessel prior to excavation of contents (by kind permission Oxford Wessex Archaeology)

In addition to the level of disturbance/truncation, derived from the archaeological records, a note of the condition of the bone itself needs to be made. As with unburnt bone, this is primarily affected by the burial environment. Well-preserved bone will have sharply defined surface morphology, but trabecular bone suffers preferentially in an acidic burial environment, often crumbling to a 'dust' fraction, whilst compact bone will appear progressively more eroded and 'chalky' (slight/moderate/heavy).

4.2 Demographic data

A major problem with cremated remains – with both age and sex estimation of adults – is the characteristic incomplete recovery of bone for burial by those performing the rite and the frequent absence of the skeletal elements most useful to the osteologist. The condition of the bone and level of disturbance to the deposit (with associated loss/increased fragmentation) are also major factors influencing our ability to estimate both the age and assess the sex of an individual. It will generally be possible to at least distinguish between 'immature' (< approximately 18 years of age) and 'adult' (> approximately 18 years) bone, and though a substantial minority will inevitably fall within the broader 'sub-adult/adult' range (>12 years), age ranges of varying size will be attributable in many instances. The future wider application of histological ageing methods may help eventually overcome these difficulties (eg, Cox 2000; Cuijpers 1997; Herrmann 1977; Hummel and Schutkowski 1993), although qualitative rather than quantitative methods need to be employed with some techniques to overcome the potential effects of shrinkage.

Most assemblages will include a substantial proportion of unsexed adults and even where sex can be indicated confidence levels may vary. The use of osteological data in the analysis of other archaeological data from the site, such as pyre/grave good associations, should always consider this shortfall to ensure the results from such analyses are not potentially misleading.

4.3 Cremation technology

Analytical techniques to explore the nature of cremated bone have been developed over many years, much of the analysis being associated with advances in forensic science (Ubelaker 2015). New approaches to understanding the effects of temperature and oxygen supply on the macroscopic (colour, fragmentation, warping – scored as absent/moderate/marked) and microscopic appearance (crystal structure, chemical composition) of the cremated bone have been developed in recent years, with particular emphasis on the latter (Beach et al 2008; Devlin and Herrmann 2008; Schultz et al 2008; Squires 2015; Thompson 2015b; Walker et al 2008). Pertinent to both archaeological and forensic settings, such data aids our understanding of how effective the cremation/burning episode was and what factors may have influenced it. However, it may be apposite to note that the requirement for 'full' oxidation of the organic components of the body is largely a requisite of modern Western crematoria, but is not necessarily considered essential within other contemporary cultures nor need it have been in the past (Barber 1990, 381–2; McKinley 2008; Perrin 1998).

Not all burnt bone will have necessarily gone through the cremation process or have been burnt green. Secondary mortuary procedures in prehistory – Neolithic, Late Bronze Age and Iron Age in particular – could involve burning or heating of dry, potentially disarticulated and fragmented bone. The classic dehydration fissures will not be present and colour changes to the bone (indicative of level of oxidation) tend to follow a less consistent pattern (see Baby 1954; Binford 1963). A note of the type and extent of fissuring should be made (curvilinear/angular/crazed; light/moderate/heavy; see also the previous edition of this chapter and above) together with a comment on colour (see previous edition of this chapter).

4.4 Radiocarbon dating, isotope and DNA analyses

A major breakthrough in the last decade or so has been the development of a reliable and accessible radiocarbon technique for use on cremated remains, which utilises carbonates trapped within the altered crystal structure of the bone during cremation (Lanting et al 2001; van Strydonck 2016). The introduction of this technique has released a massive, previously untapped resource and allows the routine analysis of samples from deposits devoid of datable artefactual material, enabling the bone and the mortuary rite to be placed in its correct temporal phase (particularly pertinent for large parts of the prehistoric period).

Radiocarbon analysis should include all unaccompanied singletons and targeted samples of small, related groups that may potentially reveal a temporal sequence; such selection would be undertaken in corroboration with other archaeological data to best serve the needs of the project as a whole. In some cases, such as for parts of the Early Bronze Age, it may be pertinent to undertake analysis of bone samples from urned burial remains to assist in more secure dating of the ceramics at the request of the pottery specialist. Care should be taken to select samples from appropriate deposit types. Fully oxidised bone (white throughout) is needed for dating, a 2g sample being the standard requirement, and it goes without saying that bone should be recorded prior to submission for any form of destructive analysis.

The analysis of stable isotopes (reflecting dietary intake and mobility history) from cremated bones and teeth is being developed but on current evidence is likely to be limited in its scope and application (Schurr et al 2008). Experimental studies, primarily aimed at forensic cases, found that strontium remained unaltered at high temperatures but that other isotope signatures were lost where bone was heated above 300°C (Harbeck et al 2011). Unerupted tooth crowns hold an as yet untapped potential for study. Experimental work has suggested that the petrous portion of the temporal bone may be suitable for such analysis (Harvig et al 2014). However, given that the technique is destructive of potentially important diagnostic elements, which can be few and of significant value within some cremation burials, careful consideration would need to be given as to the value in individual cases of undertaking such analysis at such an early stage in its development.

It is possible to source $\delta^{13}C_{apatite}$ from tooth enamel, giving a potential for a dietary signature from remains burnt at relatively high temperatures where other normal – collagen-based – C and N isotopes will degrade. The recovery of fragments of enamel from erupted teeth amongst archaeological cremated remains is, however, relatively rare. Lacking an organic component, enamel tends to shatter as it expands in the heat of the pyre and the small fragments are frequently absent from burial deposits (not recovered from the pyre site; potentially related to mode of recovery for burial). The application of this technique may, consequently, be limited and have greater scope amongst the unerupted tooth crowns from younger individuals.

Although the study of the survival, recovery and analysis of the organic materials necessary for aDNA analysis have been undertaken on cremated bone (eg, Cattaneo 1994; Wahl 2008; Walker et al 2008), aDNA does not survive at temperatures greater than 600°C (ibid; Harbeck et al 2011*)*, and potentially no greater than 300–400°C, at which point much of the organic component is oxidised.

4.5 Reports

Publication reports should include a summary, by context, inclusive of: the deposit type and its condition at the time of excavation (eg, highlighting totally undisturbed deposits/only slightly disturbed deposits), condition of the bone, quantification data (bone weight), age/sex, pathology (bone element affected, type of lesion/differential diagnosis), and the presence and type of pyre goods (including cremated animal bone).

Following presentation and interpretation of the demographic and pathological data, there should be sections considering aspects of the cremation technology and the mortuary rite including formation processes. In all areas of study the context of origin is vital, both in an archaeological and forensic setting. Improvements over the last few decades in excavation and post-excavation procedures, with greater consistency and objectivity in approach, are providing better quality site recording to assist in interpretation. Adoption, by both excavators and osteologists, of common (or at least commensurate) terminology, excavation methodology and analytical methods will allow comparison of data across broader geographic and temporal areas.

Acknowledgements

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5 Compiling a skeletal inventory: disarticulated and commingled remains

Jacqueline I McKinley and Martin Smith

The basic aims and requirements of recording and analysis of disarticulated[1] and commingled[2] human bone have changed little from those presented in the original 2004 document. There have, however, been developments in some of the techniques. Following technological advancements (both of techniques and their accessibility by osteologists) recording and reporting of data have been expanded, and the data recovered should now be more readily accessible to other workers.

Most of the focus of osteoarchaeological analyses in the last decade or so has been on prehistoric material, where the often-complex series of mortuary rites undertaken, including various forms of excarnation and curation, are reflected in the culturally manipulated deposits of human remains. Such rites are characteristic of assemblages from periods in early and later prehistory in Britain. Early Neolithic examples include causewayed enclosures such as Etton, Cambridgeshire and Hambledon Hill, Dorset (McKinley 2008a; Pryor 1998), cairns and chambered tombs (eg, Smith 2006; Smith and Brickley 2009; Reilly 2003; Whittle and Wysocki 1998), and cave deposits (Leach 2008). In the Late Bronze Age and Early–Middle Iron Age, currently rare mortuary features and deposits have been found to contain such remains (McKinley 2015), together with a more frequent occurrence in middens and settlement deposits (including hillforts; Boylston et al 1995; Brück 1995; Carr and Knüsel 1997; Hill 1995; McKinley 2008b).

Whilst continuing to have value, the conventional methods of recording skeletal remains in situ – standard photography and measured drawings in plan view – cannot create a full record of what are often complex three-dimensional deposits. The now standard use of Total Station Theodolites (TSTs) and Global Navigation Satellite Systems (GNSS) receivers in excavation to record the relative spatial positions of skeletal material in three dimensions, often in conjunction with photogrammetric imagery (ie three-dimensional virtual modelling), offer the potential for more detailed study of the formation process of such deposits than was previously possible. Other techniques for site use include laser scanning (though photogrammetry can offer the same level of accuracy with better visualisation) and manual 3D point digitisers such as microscribes (though the aforementioned techniques currently offer greater speed and accuracy). All these methods have their own limitations, including observer error, measurement limitations of the technology, cost effectiveness (time expended *versus* quality of data recovered), and no single technique or combination of techniques will necessarily suit all projects. A complementary application of multiple digital technologies needs to be tailored to individual projects, and the questions being addressed, in order to create the most useful long-term archives possible within current technological constraints (Figure 5.1).

Human bones (or fragments thereof) represent vital 'artefacts' in what is often an interconnected sequence of mortuary rites, with potentially evolving symbolism attached to different parts of the rite. The now commonplace use of radiocarbon dating gives greater precision than in the past, particularly where a sequence can be modelled. It requires only 500mg of unburnt bone, although double-dating is often advisable. Such dating helps identify temporal variations in site function and the rites undertaken. Specialist scientific analyses, such as strontium and oxygen isotope analysis, undertaken in conjunction with good context data and more precise dating, have now broadened the scope of our understanding of the range and variations in how people treated their dead.

5.1 General recording

It is imperative to record and later disseminate the data in a form that other investigators can use. Future researchers are likely to want to ask questions both with regard to a given assemblage and also to use the data to make comparisons between assemblages. The types of data to be recorded were outlined in 2004 (see also Chapter 4), together with advice on the advantages of a visual record as well as a text/digital record.

Regarding the latter, for smaller assemblages the use of spreadsheets (MS Excel or similar) may be adequate, but in general – particularly for larger and more complex assemblages – entering the data into a relational database (for example, MS Access, or Filemaker) is advised. Such applications provide better opportunities to interrogate the data in relation to multiple

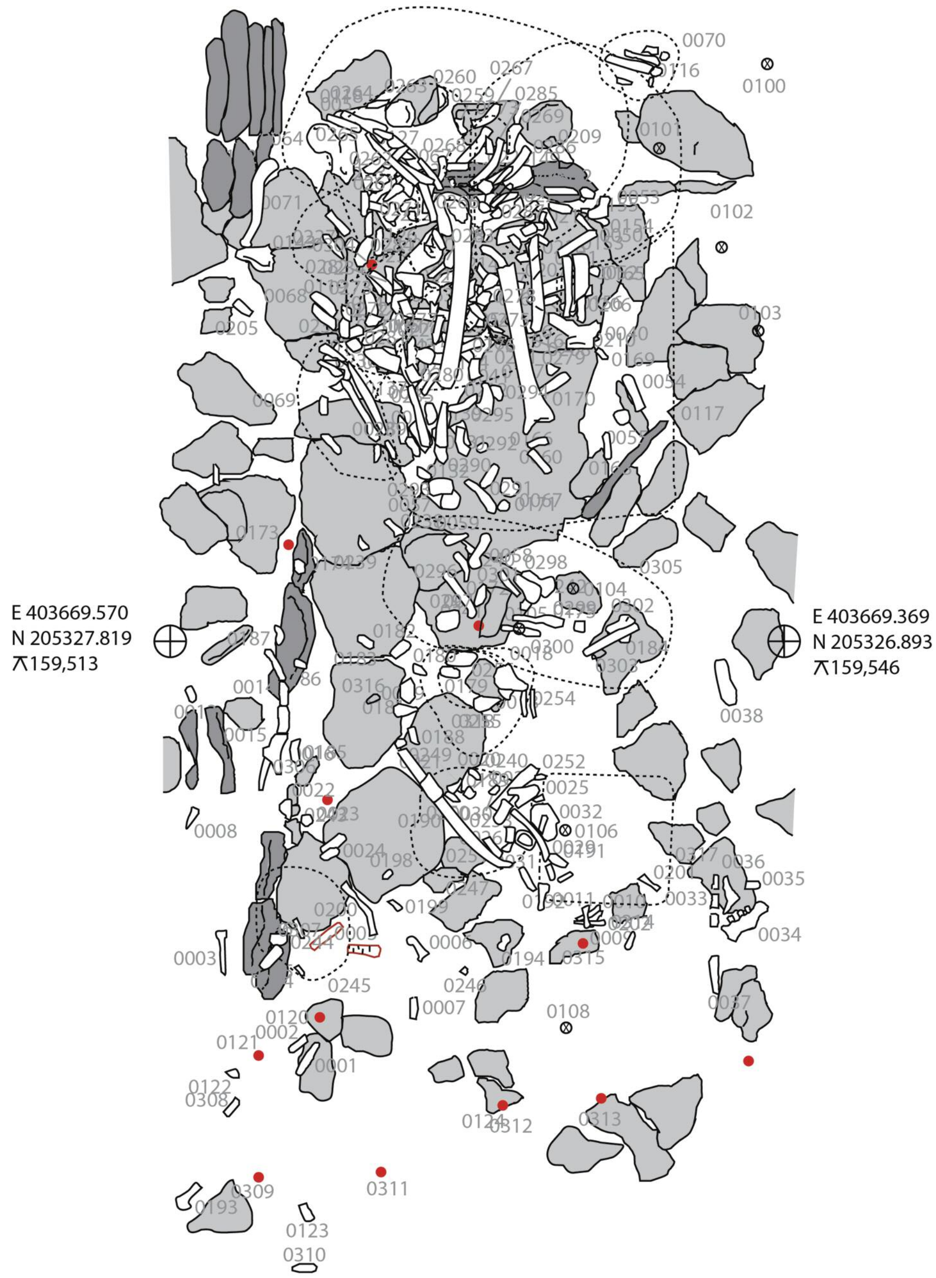

Figure 5.1 A deposit of fragmented and commingled skeletal remains from Sisters Long Barrow, an Early Neolithic chambered tomb in the Cotswolds, England, illustrating the complex and challenging nature of recording such assemblages in situ (image copyright M Smith and T Darvill)

categories simultaneously. For example, a query might want to identify all adult fragments from the left femur with signs of defleshing from amongst an assemblage consisting of thousands of fragments. In this way such applications can function to support more complex questions than are generally possible using spreadsheets alone, for which more manual filtering of the data would be needed.

To avoid handling what is often delicate material more times than is necessary (potentially resulting in further degradation of the remains), accidental duplication, or errors in copying data from written records at a later stage, it is advisable (as with all such recording) to directly input the data electronically. Such records can always be augmented later following any further analyses. The recording of skeletal material as groups or clusters, rather than individual fragments, may become necessary particularly for highly fragmented assemblages. In these cases individual fragments may be too small and numerous for separate numbering and recording to be practicable; see also the 2004 stipulation of attaching and using the site context numbers to ensure there is no confusion over the origin of the material and its link to the rest of the site archive. It is imperative that the two sets of data can always be related both in the current and any future analyses. Bones that have already suffered a high degree of breakage are also susceptible to further fragmentation post-excavation, regardless of how carefully they are handled, and therefore recording clusters of material in this way allows for the possibility that the number of fragments comprising a cluster may change over time.

With such material, often presenting as small fragments subject to human and animal manipulation in addition to other forms of bioturbation and disturbance in prehistoric assemblages, the calculation of the minimum number of individuals (MNI) requires careful examination and recording of each fragment. Morphologically distinctive skeletal markers will need to be recorded individually as precisely (for skeletal location of the fragment) and in as much detail as possible. Large parts of an assemblage will often need to be laid out together to enable potential refitting or pairing of elements to be checked. Calculation of the MNI is undertaken using the most frequently identified skeletal element (which may comprise a relatively small part of one element), in combination with morphological observations pertaining to the indicated age and sex of individuals.

The advantages and potential limitations of the use of a coding system to record the skeletal elements present (or parts thereof) were discussed in 2004. Knüsel and Outram (2004; 2006) devised such a coding system, applying the zonation method. The use of some form of electronic recording – database or spreadsheet – of the skeletal elements represented is undoubtedly necessary. It acts as a tool for calculating minimum numbers of individuals, for understanding the nature of the assemblage, and for rapid detailed interrogation of the data (see above). However, an accompanying visual and text record remains advantageous with assemblages of this nature. This is because such detail is often vital not only for the MNI, but for interpretation of cultural manipulation and other taphonomic processes. It may also be useful to photograph the bones/fragments that make up an assemblage individually with their sample bags/labels visible in order to facilitate any future assessment by providing a record in case of future breakage or mixing of material.

The use of Scanning Electron Microscope (SEM) imagery was advocated in 2004 to assist in the investigation of cut marks and help distinguish them from other potential pseudo-cultural modification such as that resulting from animal trampling (Andrews and Cook 1985), root etching (McKinley, 2004, fig 6; see also Smith and Brickley, 2009, 48) and the linear impressions made in bone by blood vessels (Fernández-Jalvo and Andrews 2016). Whilst SEM is often useful in helping to resolve the source of such marks it can involve lengthy sample preparation and older equipment lacks the facility for three-dimensional recording or measuring dimensions, and furthermore may not be readily accessible by commercial osteologists. By contrast, digital microscopy is generally quicker and simpler, whilst offering the opportunity to record and measure the profile of defects in section, which is often helpful in distinguishing genuine from pseudo-cut marks. Confocal microscopy (or confocal laser scanning microscopy) can produce images with higher resolution and greater measuring accuracy than standard digital microscopy, whilst both techniques can generate three-dimensional models of bone surface features. Again, as with the use of digital technologies in general, the technique chosen will commonly depend on the facilities available to individual researchers and the nature of the question being addressed.

5.2 Reports

The provision of access to original datasets (the archive data) is now becoming the norm in academic research and spreadsheets (MS Excel or similar) are readily distributed as supplementary material to online publications. Furthermore, information recorded using a database can be converted to a spreadsheet format enabling such data to be uploaded.

Where assemblages of this nature are subject to excavation, recording and analysis by commercial archaeological organisations, full summaries of the material and discussion of the various categories of data recovered are required. These should be made available by publication either as a monograph, or in a national or county journal, or occasionally on the organisation's own webpage (depending on the size and/or significance of the site). The full, detailed, osteological archive, inclusive of the database records, text and visual records, is usually deposited with the rest of the site archive at the appropriate county museum or, where the latter have no available storage facilities (a growing difficulty in the UK; McKinley 2013), held by the archaeological contractor. Most archives are now deposited digitally, although some may still comprise hard copies. Although some archives may be stored online, either on an organisation's own webpage or deposited via the Archaeology Data Service (ADS), this is not yet standard practice and would potentially have substantial cost implications.

A summary of the findings from commercial archaeological investigations is generally recorded on OASIS (Online AccesS to the Index of archaeological InvestigationS; a centralised Historic Environment Record hosted by ADS) irrespective of the level of recording, analyses and publication undertaken. Not all planning conditions require full publication and clients may not be compelled to pay for full analysis and publication in some circumstances. OASIS is shortly to be replaced by the more sophisticated HERALD system (Historic Environment Research Archives Links and Data), which should enable greater interrogation of data, but the ADS, or storage facilities outlined above, remain the source of detailed information/grey literature. It should be noted that osteoarchaeological reports produced by practitioners in the commercial sector form part of an overall programme of archaeological investigations. It is the responsibility of the archaeological project manager to disseminate the data from their projects, not that of individual team members (which would include the osteoarchaeologist).

Endnotes

1 For the purposes of the current chapter the term 'disarticulated' is used to refer to circumstances in which skeletal remains are encountered in spatial positions that are at variance from the normal anatomical relationships between different bones during life. As such, disarticulation may occur through both natural taphonomic processes and/or anthropogenic post-mortem manipulation or disturbance of remains. Of course, all buried remains are liable to some degree of movement in the ground, particularly during the processes of decomposition. However, for the purpose of the current guidelines, bones are regarded as remaining in 'articulation' if their positions relative to each other do not differ substantively from those found in life, notwithstanding normal 'settling' during decomposition, for example – see Willis and Tayles (2009) for further discussion of the latter.

2 In the current chapter the term 'commingled' refers to instances where disarticulated skeletal material from two or more individuals has become spatially intermixed either through natural taphonomic processes or through anthropogenic manipulation or disturbance.

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6 Guidance on recording age at death in adult human skeletal remains

Linda O'Connell

6.1 Introduction

Age at death is one of the fundamental biological parameters assessed as a part of skeletal analyses – to either examine secular change or assist identification. Methods employed basically attempt to correlate chronological age (a constant, predictive, linear progression) with physiological variations reflective of either developmental or degenerative change (a discontinuous and saltatory process). As a consequence, the continuum of growth, development and remodelling has been divided into imprecise artificial stages that are based on macroscopic characteristics, rather than scientific principles. This basic disparity is further complicated by the complexity of the ageing process and the innumerable intrinsic and extrinsic variables that influence it (Mays 2015). Furthermore, because few growth processes continue during adult life, estimation is almost entirely dependent on degenerative changes that occur at differing rates in, and within, different populations and samples.

Macroscopic examination of the skeleton is a less protracted and inexpensive process compared to methods that employ medical imaging techniques or microscopic investigation and it is this approach that will be considered in this chapter.

6.2 Methods

Before implementation of any technique, practitioners should have an understanding of how methods were originally developed and tested, and any inherent biases in that. Readers are therefore directed to the 2004 edition of this chapter for further details of sampling, testing methods and palaeodemography.

6.3 Final stages of maturation – identifying young adults

Several areas of the skeleton complete maturation during the late second and third decades of life and so can be employed to identify those dying in early adulthood. This marks the ultimate concluding stages of skeletal maturation and does not include indicators employed for assessment of pubertal stage and adolescence.

Vertebral epiphyses

Albert and Maples (1995) initially reported non-union of annular rings prior to 14 years (females) and 16 years, 4 months (males). The youngest age to exhibit complete union in all vertebrae was 25 years (female) and 24 years, 2 months (male). Recent work by Cardoso and Ríos (2011) found partial union from 14 to 27 years of age (thoracic) and from 14 to 23 years of age (lumbar).

Sacrum

Generally speaking, if spaces can be detected between the vertebral bodies of the sacrum, the individual is younger than 20 years of age. If space is only observable between S1 and S2, then the individual is probably less than 27 years of age. Complete fusion is usually observed from 25+ years (Cunningham et al 2016, 218).

Medial clavicle

The absence of a medial epiphysis suggests an age less than 18 years. A well-defined fusing flake will usually be present around 16–21 years and, by 24–29 years, the epiphysis will cover most of the surface (Cunningham et al 2016, 261). Cardoso (2008) reported sex-specific fusion data of between 17 and 27 years (females), and between 19 and 25 years (males). Generally speaking, fusion is not usually observed before 22 years of age and is always complete by 30 (Cunningham et al 2016, 261).

Iliac, ischial and ramal epiphyses

In the iliac crest, ossification commences around 12–13 years in females and 14–15 years in males (Cunningham et al 2016, 373), with partial fusion evident from 14 to 26 years and 15 to 24 years respectively. Complete fusion is attained by 26 years of age (Cunningham et al 2016, 376). The ischial epiphysis begins development around 13–16 years and continues inferiorly as the ramal epiphysis, around 16–18 years. By 19–20 years, it extends halfway and finally fuses between 14 and 26 years in females, and between 15 and 24 years in males (Cunningham et al 2016, 376).

Spheno-occipital synchondrosis

Spheno-occipital fusion occurs at end of the adolescent growth spurt and when the permanent dentition (except the third molar) is nearing completion – that is, between 11 and 16 years in females and 13 and 18 in males (Cunningham et al 2016, 68). Recent reviews concur that complete fusion is likely to occur during adolescence (Krishan and Kanchan 2013; Lottering et al 2015).

Petroexoccipital articulation (jugular growth plate)

Maat and Mastwijk (1995) and Hershkovitz et al (1997) ascertained that no fusion was detected in males and females prior to 22 years. Unilateral fusion was observed only between 22 and 34 years, and at ages above 34 years (females) and 36 years (males), fusion was bilateral. Fusion can, however, occur up to 50 years of age and, in a small minority, not occur at all.

6.4 Degenerative change in the skeleton – identifying mature adults

Pubic symphysis

Assessment of age is undertaken by employing descriptions published by Brooks and Suchey (1990) with the twelve pubic bone casts (male and female), illustrating the six phases of their age determination system. Hartnett (2010a) recently revised this method, creating new descriptions and age ranges, and introduced a phase seven that comprises males and females over 70 years of age at death.

Auricular surface

Although the auricular surface is more complex and difficult to score, this area is more frequently preserved. Falys et al (2006) tested Buckberry and Chamberlain's (2002) individual component scoring system and found that although trait composite scores generally correlated with age, when combined to define particular developmental stages, only three distinct ones could be identified and statistically supported (compared to the original seven). This indicates that this method may be indicative of broader age categorisation, rather than narrower delineation.

Sternal end of rib

Earliest schemes were originally devised for ageing the fourth rib, but later work has demonstrated no great difference between the second through to ninth ribs (Yoder et al 2001). Hartnett (2010b) recently revised this method and calculated summary statistics for each new phase, with a variant form of the rib end additionally being described. Kurki (2005) demonstrated age-related morphological change in the more-often-preserved first rib. Although inaccuracies and bias were identified with this approach, it was noted that these were relatively low in comparison to those inherent in established ageing methods and so therefore potentially useful for application to older age categories.

6.5 Ageing from the dentition

Third molar development

Liversidge and Marsden (2010) reported that although significant bias was demonstrated, if this tooth is mature, then 18 years has more than likely be attained. Isolated employment of this approach demands caution, but may prove useful in combination with other methods for identifying young adults (Fieuws et al 2015).

Dental wear (attrition)

Probably the most widely used dental scoring scheme for archaeological samples is that developed by Brothwell (1981, 72), although Miles's (1962) system is also implemented. However, stages do not represent a series through which all dentitions pass in an ordered, steady sequence. Nevertheless, age at death may still be determined if the diet and rate of attrition of a particular population can potentially be inferred from ethnographic, iconographic, documentary or clinical evidence.

Lamedin two criteria method

This approach employs observations of tooth root translucency and gingival regression in an unsectioned, undamaged, non-carious ex situ tooth (Lamedin et al 1992). It may be implemented as part of the two-step procedure (TSP), which advocates both the Lamedin and Suchey-Brooks methods (Baccino et al 2014).

6.6 Cautionary note

There are some methods that are not recommended for general use, due to their inaccuracy and unreliability: cranial suture closure, arachnoid granulations, and ossification of hyaline cartilage.

6.7 Recording age at death

It is essential that the methods employed to estimate age at death are clearly identified and stated. Precise notes should be kept for each individual on the recording forms used (eg, stage/scores awarded for each feature observed) and descriptions tendered where appropriate. This will allow reassessment, re-evaluation and refinement of methods by future researchers.

There appears to be minimal guidance, however, on how individual age estimates should actually be combined, weighted or presented to provide an overall age estimate (Buckberry 2015). In most cases it would seem that subjective experience is employed, rather than a consistent approach utilising age ranges, areas of overlap, mean ages or standard deviation (Garvin and Passalacqua 2012) – a system which research does tend to suggest may well be more accurate (Milner and Boldsen 2012).

With regard to the numerical recording of estimated ages, it is recommended that mean, standard deviation and all ranges (95% or 100%) relevant to each method should be documented. Results should then be presented in two ways – as a full, outer, wide inclusive age range incorporating the youngest and oldest ages suggested by all indicators, and as an area of overlap, or consensus, that reflects all indicators in accordance. Lynnerup et al (2008, 5) refer to these as 'would not exclude' and 'most likely to be' categories respectively. However, recent work at Fromelles clearly demonstrated that even when wide outer inclusive age ranges were utilised, some of the identified soldiers' actual ages still fell outside of this anthropologically estimated range (Cox and Loe, in prep), with around 80% falling within the likely range up to 25 years (real age) and thereafter decreasing considerably (M Cox, pers comm).

Traditionally, individuals have been subdivided into specific age groups for the purpose of comparative research, be that large arbitrary qualitative age categories, narrower banded designations, or computer-assisted transformations employing the Halley Band construct (Luy and Wittwer-Backofen 2008, 124). However none of these approaches are sagacious, given current limitations of age assessment and the fact that populations do not remain both uniform and stationary across time.

An alternative approach, suggested by Roksandic and Armstrong (2011), suggested basing categories on life history patterns of development and senescence, arguing that this could assist with the development of ageing methods that utilise life stages, rather than point age estimates (ibid). Indeed, because life histories evolve to maximise reproductive success, fecundity is linked formally to population models (Bradshaw and McMahon 2008, 1543). Systematic study of the three major ecological stages of a population may therefore be warranted from the skeletal perspective in future.

6.8 Concluding remarks

The biological basis of physiological age change, and the various intrinsic and extrinsic factors affecting it, is complex. It is therefore imperative that methods employed to assess age are accurate, valid, reliable, performance proved and based on sound scientific principles. Current determinations employ multiple indicators, balanced against accepted reliability of method (Falys and Lewis 2011). None of the methods currently available are totally reliable or accurate and those undertaking implementation and recording have to work within the limitations of the techniques and with appropriate caution.

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7 Estimation of juvenile age at death

Jo Buckberry and Megan Brickley

7.1 A note on terminology

In recent years there has been an increasing awareness of the level of certainty used when analysing human remains and the use of language used to express this certainty. Because of the poor correlation between biological age and chronological age, the term age estimation is preferred to age determination. Age categories are commonly employed, but where used, individual-specific age estimates should be provided (Buckberry 2015; in press). A number of authors have started to push beyond simple consideration of chronological and biological age, and have begun to use these data as a foundation to discuss the social age of individuals in past communities (eg, see Sofaer 2011; Halcrow and Tayles 2011). Social ages are culturally specific, with considerable variation in the age of transition between age groups in different societies. Any age categories used in reports should be defined, and researchers need to be aware that the chronological ages applied to terms such as 'infant' 'child' or 'juvenile' in published reports have varied widely.

Increasingly the term 'non-adult' is being used in place of 'sub-adult' to refer to any individual under *c*18 years as the latter term could be seen to have negative connotations (Lewis 2007, 2). Both terms are in common use at present.

7.2 Dental development

Dental development and dental eruption are still regarded as the most accurate method for estimating non-adult age at death. Recent publications have supported the view that dental development in particular is resistant to detrimental external factors such as malnutrition (Elamin and Liversidge 2013; Liversidge 2015); however, in cases of extreme metabolic disease in individuals of known age, even dental development can be retarded (Ives 2015). Recently, Liversidge (2015) reviewed age estimation based on the development of the second permanent molar and noted that age variation occurs for all tooth stages. She stressed that age should be expressed as a range rather than a point estimate, to reflect this variation.

The London Dental Atlas (AlQahtani et al 2010) was developed on a large British reference population, including both white and Bangladeshi individuals. It should be noted that while radiographs were used for individuals over the age of two years, dissected and archaeological material (Maurice Stack Collection and Christ Church Spitalfields respectively), examined macroscopically, was used for the youngest individuals. This means that initial stages of deciduous dental development, identified entirely radiographically or histologically in other studies of dental development (eg, Christiensen and Kraus 1965), may be underrepresented in the London Dental Atlas due to their small size. Users need to be aware of the differences in histological and macroscopic data sets (Liversidge, pers comm 2015). A recent test has found better accuracy for the London Dental Atlas when compared to Schour and Massler (1941) and Ubelaker (1978); however, all three methods tended to underage older individuals (AlQahtani et al 2014). It would be beneficial to see an independent test of the London Dental Atlas, undertaken by a different research group, and to see it compared with other atlases, such as Gustafson and Koch (1974).

7.2 Microscopic examination of teeth

With regard to incremental structures in teeth it remains the case that methods are unlikely to be applied on a regular basis. Recent publications that might be of interest to those considering utilising these methods include FitzGerald and Saunders (2005), Antoine et al (2009), Reid and Dean (2006) and Mahoney (2011; 2012).

7.4 Development and maturation of the skeleton

Scheuer and Black (2016) is the most comprehensive and up-to-date review of skeletal growth and development, with abridged versions also published (Scheuer and Black 2004; Schaefer et al 2009). Studies of specific populations and/or joints have been published (eg, Coqueugniot and Weaver 2007). Many recent publications focus on establishing specific ages in living individuals (see Márquez-Grant 2015 for a recent review). The epiphyseal scar (visible on radiographs) has been shown to be retained for decades after fusion (Davies et al 2015). The implications for the persistence of epiphyseal lines (visible on dry bone) are not yet known, but it is possible that these may also persist long after fusion has occurred.

A new method has been proposed for estimating pubertal stage from the development of the canine root and hook of hamate, the fusion of the iliac crest, distal radius and hand phalanges and the maturation of cervical vertebrae (Shapland and Lewis 2013; 2014). A recent test using a documented sample showed the method to be consistent with expected ages of attainment for different stages and for documented age at menarche, but cautions users to consider asymmetrical development of the features (Henderson and Padez 2016).

In terms of bone size (most frequently long-bone length), studies have continued to show that archaeological individuals often have short bones for their dental age when compared with data from modern growth studies, and that the disparity increases with increasing age. This may be, in part, due to the (dead) children having retarded growth (see Mays, in press, for a more recent review of growth studies). By investigating the relationship between dental age and long-bone length it is possible to develop population-specific standards for age estimation from long-bone lengths for children that did not survive into adulthood, for use when the dentition is not recovered (eg, Primeau et al 2016). This approach assumes that dental development has been minimally affected by external stressors, and that rates of growth were similar between individuals who died during childhood in the population. However, it is impossible to ascertain if the resultant age estimates are more accurate that those derived from modern datasets. Further formulae for estimating age from bone dimensions (eleven measurements from the femur, scapula, os coxae and tibia) have been developed on European 19th- and 20th-century populations, giving r^2 values of 0.871 to 0.970 (Rissech et al 2013); again these formulae require further testing and may not be equally applicable to pre 19th-century populations.

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8 Undertaking sex assessment

Megan Brickley and Jo Buckberry

Ideas on the level of certainty that we can have when evaluating biological sex have developed considerably since the publication of the BABAO guidelines in 2004. The title of this chapter has therefore been changed from 'sex determination' to 'sex assessment'. For discussion of the term 'estimation' see Section 8.3 Metrical evaluation.

In the last ten years there has been a real development in attempts to consider gender in addition to biological sex (see review in Hollimon 2011). Consideration has been given to differences between biological sex and socially constructed identities using both biological variables and mortuary evidence. The possibility of non-binary gendered individuals and changes in individual social identity through the life course have also been discussed. Researchers should carefully consider all terms used in reports. Brief, clear explanations of how terms employed are used should be provided.

8.1 Non-adults

Researchers have continued to investigate the possibility of assessing non-adult sex using morphological and metric traits, but these still produce levels of accuracy that are often quite low (<85%). It has been argued that some traits vary with increasing age, rather than between the sexes (Vlak et al 2008). In recent years aDNA techniques have developed considerably; this type of approach has significant potential in the investigation of sex of both non-adult and adult human remains. Information on recent developments is provided by Skoglund et al (2012).

8.2 Adults

The morphological features used to assess sex are, by and large, the same as those used in 2004, and the guidance on using temporally and geographically comparable material for comparison still stands. Recently there has been increasing emphasis on reproducibility and reporting of accuracy levels for methods. As a result, discriminant functions or linear regression formulae have been developed for some morphological sex assessment methods that combine traits and produce a percentage likelihood of an individual being male or female (Walker 2008; Klales et al 2012). For the pubic traits this has included the development of a five-stage visual recording system for all three of the Phenice traits (Klales et al 2012). Spreadsheets for using the functions set out by Klales and colleagues are available at http://nonmetricpelvissexing.weebly.com/ and by Walker (2008) at http://math.mercyhurst.edu/~sousley/Software/ It is recommended that these are used in preference to the diagrams in the 2004 edition of this volume.

Statements made in the 2004 edition of this volume on the utility of features of the mandible for assessment of sex in human remains from British sites still stand.

For other features of the cranium and pelvic bones not dealt with here, the reader is referred to Buikstra and Ubelaker (1994). The Buikstra and Ubelaker volume also lists categories that are widely used following assessment of sex.

8.3 Metrical evaluation

Many people now use the term sex 'assessment', but it has been suggested by Moore (2013, 91) that the term 'estimation' might be better when using metric techniques that have an estimable error rate. As ever, terminology is developing and those writing up reports and research should consider which term is most appropriate for their work. A brief summary of developments in use of terminology is provided by Moore (2013, 92). Extensive literature is now available on metric sex evaluation using different skeletal elements and dentition. Data has been gathered on individuals from a number of geographic regions and it is recommended that researchers considering metric evaluation of sex should select individuals with comparable genetic composition to the collection under study. Secular change has also been noted to play an important role in height and size of various groups investigated (eg, see Hoppa and Garlie 1998), which may affect the reliability of metric sex methods applied to individuals from different time periods.

8.4 Parturition

The statement on using skeletal indicators of parturition still stands. There are no skeletal features of the pelvis that can be used to provide statements on parity. See the review by Ubelaker and De La Paz (2012) and McFadden and Oxenham (2017).

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9 Guidance on recording ancestry in adult human skeletal remains

Linda O'Connell

9.1 Introduction

Within the scope of human skeletal analyses, ancestry relates to biological affinity (as opposed to any social, cultural, political or religious concept of the term) and has been defined as the 'biogeographic population to which a particular individual belongs, by virtue of their genetic heritage' (Barker et al 2008, 322).

The concept of biological ancestry essentially pertains to the physical variation that arises as an adaptive response to success and may be described in terms of genetics (genotype) and appearance (phenotype). However, in reality there are basically no human skeletal markers that correspond perfectly to geographic origin (White et al 2012, 423). Indeed, some anthropologists avidly reject the notion that humanity can be separated into a finite number of distinct taxonomic racial subdivisions.

Nevertheless, due to demonstrable correlations between phenotypic and genotypic similarities, measures of biological distance in bioarchaeology have tended to be established through the employment of quantitative methods to metric and non-metric variation. However, Orgogozo et al (2015) noted that the relationship between genotype and phenotype is an extremely complex interaction and proposed the differential concept of the gene for understanding the genetic and environmental effects on phenotype and their connections.

In regard to craniofacial and mandibular morphology, variation therein is recognised as a reflection of population histories transpiring subsequent to events such as migration/expansion and consequent selective pressures on different regions of the skull (Galland et al 2016; Paschetta et al 2010). Although some aspects of cranial morphology are susceptible to climactic adaptation (Hubbe et al 2009), other research has demonstrated that phenotypic distance and patterns of craniometric variation tend to correlate with neutral genetic distance globally and are consistent with neutral traits under an isolation by distance model (Betti et al 2010; Roseman 2004; von Cramon-Taubadel 2009).

Despite the limitations and fluctuating popularity of this analysis, ancestry remains an important element in the construction of biological profiles in archaeological, historical and forensic contexts, be that for purposes such as life history reconstruction, repatriation or identification. As such, the complexities inherent in this very specialised and contentious area of study need to be borne in mind when considering the various methods currently available for determination of this parameter. It is absolutely vital that researchers studying human skeletal material should have a comprehensive understanding of normal and associated biological variation and apply a holistic approach in implementation of methods, in order to critically address assigned biological characteristics. This necessitates working, with caution, within the limitations of the techniques and by applying appropriate provisos and caveats. Advice from a specialist would also be beneficial.

9.2 Methods

It is a well-known fact that sex, age at death and stature exert an immutable dependency on one another – but these also have a substantive influence on many of the traits used to ascribe ancestry. In as far as order of analysis is concerned though, it would appear that anthropologists remain divided over which parameter should be performed initially.

Sequencing aside, the determination of ancestry essentially incorporates two approaches – osteometric and morphological (visual assessment).

9.2.1 Morphological assessment

Although visual assessment of both cranial and postcranial elements may be undertaken, the determination of ancestral affinity is usually based upon gross morphological examination of certain skeletal traits in the skull (Brues 1990; Gill 1998; 2001, İşcan and Steyn 2013, 197, 205–211; Rhine 1990; St Hoyme and İşcan 1989, 69–75). These craniofacial traits are summarised in tables by Barker et al (2008, 32) and İşcan and Steyn (2013, 197). Useful diagrams and photographs are also provided by Gill and Rhine (1990) and İşcan and Steyn (2013, 205–211).

The expression of each of these is documented and results evaluated. A cranium exhibiting a preponderance of traits of a single ancestral population is usually assigned to that ancestry. If a mixture of traits is evident, then a mixed ancestry should be recorded. Assessment should not be undertaken on skulls exhibiting plastic deformation, major reconstruction or pathology, or in cases where fragmentary remains exhibit less than 50% of observable landmarks (Barker et al 2008, 325).

With regard to postcranial elements, a number of areas have been studied, with the femur providing perhaps the greatest value in determining ancestry so far. Observations relating to the degree of anterior curvature of the femur (Ballard 1999; Gilbert 1976; Gill 2001), subtrochanteric shape (Gilbert and Gill 1990; Westcott 2005) and intercondylar shelf angle of the distal femur (Craig 1995; Berg et al 2007) have all been employed.

Primary dental and skeletal non-metric traits (see Chapter 10) can also assist the assessment of ancestry and are simply recorded as present or absent. This method, however, is problematic, due to the varying aetiology of the traits concerned. Any approach to employing it therefore needs to be based on statistical analyses from which known accuracy and reliability values can be obtained.

Only very broad classifications of ancestry can be achieved by the employment of visual techniques. Whilst this may appear to oversimplify the relationship between biological expression and genetic affinity, visual techniques do provide a useful method for broadly classifying individuals and identifying those whose features vary in relation to the rest of a sample/group.

Although morphological approaches to ancestry determination tend, at present, to only be applied to adult skeletal remains (due to a paucity of peer-reviewed methods in juveniles), it is recognised that anthropologists with extensive experience of working internationally, and/or with human remains from diverse ancestral groups, may be aware of distinguishing features (Barker et al 2008, 324) in both skeletal and dental components.

9.2.2 Osteometric assessment

Metrical analyses can be applied to both cranial and postcranial elements, although generally speaking the former are mostly employed for ancestry determination. Methods for analysing relevant quantitative data tend to focus on the application of multivariate statistical procedures, as these are considered the most robust available for such analyses (Pietrusewsky 2008).

Formulae and associated software programs exist to allow geographic classification according to measurements of the cranium. These include CRANID (Wright 2012) and Fordisc (Ousley and Jantz 2005). 3D-ID (Slice and Ross 2009) performs classification using coordinate data. Fordisc utilises the Forensic Data Bank (13 groups with 1845 individuals), Howells' Global Dataset (28 groups with 2524 individuals) and a 19th-century population sample (two samples with 324 individuals). CRANID's database consists of a larger world sample of 74 groups, representing 3163 individuals.

Proponents of these methods argue that worldwide craniometric variation demonstrates a robust geographical configuration. However, such programs are only as useful as the data they are based upon and reference samples tend to be heavily biased towards particular ethnic groups or comprise a mixture of archaeological and modern samples. Consequently, Fordisc is more favourable for cases in North America, whilst CRANID is better for isolating individuals of a European ancestry. As such, the application of these software programs to samples not adequately represented within the reference measurements has been regarded as unreliable and limited (Elliot and Collard 2009).

9.3 Cautionary note

Although the application of the aforesaid methods may seem straightforward, there are accepted limitations. Research has shown that certain anatomical cranial regions reflect higher correlations with molecular distances than others (Smith 2009; von Cramon-Taubadel 2009), and the reliance of morphological methods on subjective trait lists (which may be influenced by a variety of factors), is widely accepted. Hefner et al (2012) argue that a more scientific approach, based on trait consideration within a solid statistical framework, is warranted, rather than morphological trait identification, based on observer experience and trait distributions. Hefner and Ousley (2014) employed Artificial Neural Networks (ANN), Optimized Summed Scored Attributes (OSSA), Support Vector Machines (SVM), and random forest models to demonstrate that morphoscopic traits could be successfully used to assess ancestry without relying solely on the experience of the observer. Most recently, Hefner (2015) proposed a method of assessing ancestry using a combination of seven morphoscopic traits and discriminant function analysis.

9.4 Other approaches

Biomolecular methods can employ specific DNA markers to predict an individual's ancestry, as well as revealing routes of ancient human migrations (see Chapter 13). Multidisciplinary approaches, employing carniometric data and stable isotope analyses, may also provide information on possible levels of migration and diversity (Dupras and Schwarcz 2001; Leach et al 2009; Price et al 2000; Sealy et al 1995).

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10 Metric and non-metric studies of archaeological human bone

Sonia Zakrzewski

There has been relatively little change in the use of metrical and non-metric research in Britain since the original publication of these guidelines in 2004. As noted in the chapter on the determination of sex, metric methods may be applied to aid in the assignation of sex to skeletons, but this is normally undertaken only as an addition to morphoscopic methods or when such morphoscopic traits are not preserved. The biggest change since 2004 has been in the use of geometric morphometrics (GM) for university academic research into shape and pattern. These methods are not applicable for most field and contract analysis situations and so will not be discussed here; for details, please consult McKeown and Schmidt (2013), Mitteroecker and Gunz (2009) and Weber and Bookstein (2011).

There has been a long history of craniometric studies in the UK, including the large volume *Crania Britannica* published in 1865 by Davis and Thurnam. However, apart from the doctoral research by Russell (2007), little further research has been undertaken since the synthesis by Mays (2000). By contrast, around the world, this field has developed in order to answer more theoretically nuanced questions, such as regarding identity (Nystrom 2006; Stojanowski 2005), differences in gene pools and the impact on disease prevalence (Ortner 2011), residential and other mobility, including kinship structures (Česnys and Tutkuvienė 2007; Shimada et al 2004) or intracemetery models (Stojanowski 2013; Stojanowski and Schillaci 2006) and models of isolation by distance (Ossenberg et al 2006; Zakrzewski 2007). Outlines of the key theoretical and methodological frameworks are well discussed (eg, see papers in Pilloud and Hefner 2016). Recent research focusing on cranial morphology has tended to use geometric morphometric methods in order to add nuance to models of migration, degrees of heritability and founder effects (see Pinhasi and von Cramon-Taubadel 2009; Smith 2009; von Cramon-Taubadel 2009). Despite detailed studies of both cranial and post-cranial non-metrics (Hauser and De Stefano 1989; Ossenberg 2013; Saunders and Rainey 2008), recent biodistance studies have tended to focus upon dental non-metric traits, usually scored following the Arizona State University Dental Anthropology System (ASUDAS) methods (Turner et al 1991; see also Scott et al 2016; Figure 10.1). Albeit not working with British skeletal material, this field has been pushed forwards by Joel Irish (e.g., Irish 2006; 2010; 2016). The recommendation therefore remains to record presence, absence and/or unobservable for standard cranial and post-cranial non-metric traits (see Buikstra and Ubelaker 1994; Mann et al 2016).

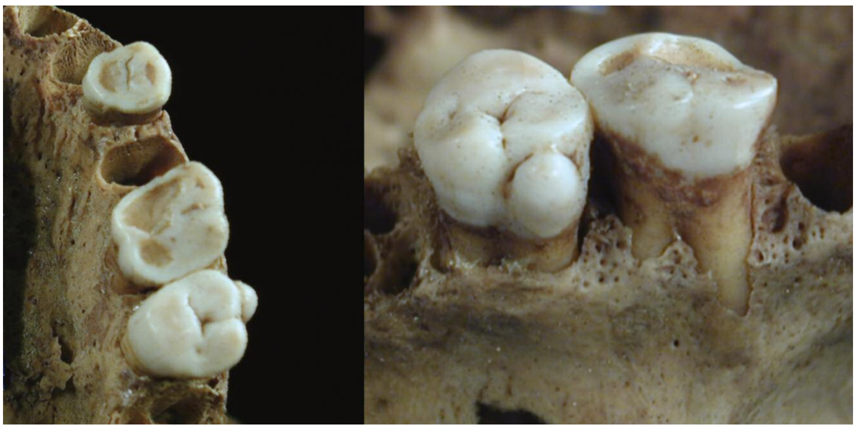

Figure 10.1 Example of ASU UM parastyle (Predynastic Egyptian Female). Image: Sonia Zakrzewski

In quite marked contrast to craniometrics and non-metric trait analysis, major theoretical developments have occurred in the analysis of skeletal body size and shape (Auerbach 2011; Auerbach and Ruff 2006; Cowgill et al 2012; Raxter et al 2006; 2007; Ruff 2008; Ruff et al 2006; Temple et al 2008). These have been pioneered in Britain primarily by Jay Stock and colleagues (Kurki et al 2010; Stock 2006; Stock and Shaw 2007; Wells and Stock 2007). Although long-bone measurements have been used to assess mobility and activity, stature reconstruction remains the most common use of metric analysis within British osteological contexts. It is worth noting that, especially in forensic situations, soft tissue correction factors might need to be applied, whatever the method of stature determination is used. Full skeleton methods, such as the Fully method for stature estimation (Raxter et al 2006; 2007) have become more accessible with the advent of mechanisms to correct for missing elements (Auerbach 2011). Full skeleton methods such as the Fully method also have the benefit of not requiring sex estimation in advance of their application, and additionally provide greater accuracy when the individual being assessed had an anomalous number of vertebrae or unusual body proportions (Raxter and Ruff 2010). In British contract osteological situations, however, regression methods, as outlined in the original recording guidelines, remain the most commonly applied method for the estimation of stature reconstruction. There are no clear reference samples and prediction equations with which to compare British skeletal remains. As a result, it is imperative that body shape is considered when applying regression-based stature prediction equations and that the most appropriate equations are chosen for each individual and each sample being analysed. Since the publication of the original version of the recording guidelines, many new stature prediction equations have been published, such as those using long bones (Petrovečki et al 2007), phalanges (Habib and Kamal 2010) or the vertebrae (Pelin et al 2005), but their application and reliabilities have not been widely tested. As a result, the methods described in the original guidelines usually remain the most appropriate.

In the original guidelines, however, we did not make some aspects of measurements completely clear and so brief clarification is included here, but for a more detailed discussion, see Mays (2016).

The equations presented in Trotter and Gleser (1952) derive from US military casualties from World War II. These individuals might not have body shapes representative of or similar to those of the archaeological remains being studied. Those from Trotter and Gleser (1958) derive from Korean War dead. The equations presented in Brothwell (1963 and later editions) are, for females, developed from American World War II casualties (Trotter and Gleser 1952), and for males, developed from American casualties from the Korean War (Trotter and Gleser 1958). Trotter herself preferred the 1952 equations and later recommended them for both males and females (Trotter 1970). Given this, the 2004 guidelines presented the World War II equations for use with males (Trotter 1970; Trotter and Gleser 1952). Furthermore, issues arise with the measurement of the tibia (Jantz et al 1994; 1995). If using the equations derived from the Korean War dead (Trotter and Gleser 1958), the tibial measurement should include the malleolus (ie, LCT – as described in the original version of these guidelines – or TiL_1 (Brothwell 1963)). In contrast, if using the World-War-II-derived prediction equations (Trotter and Gleser 1952) – those recommended in our original guidelines – Jantz et al (1994, 528) state clearly that ‘maximum’ tibial length should be measured ‘from the most proximal part of the lateral half of the lateral condyle to the most distal projection of the bone, not including the malleolus’. This does not directly equate with TiL_1 (Brothwell 1963) or LCT but is approximately 11mm shorter (Jantz et al 1995).

It is imperative to focus on the body shape of the individual and to use the most appropriate series of equations for the relevant body shape of the skeleton being assessed. This means employing all the possible equations and then finding which series of equations leads to the smallest range or spread of stature predictions, and, from within that series with the smallest range, then using the equation with the lowest associated standard error. The assigned ‘race’ does not represent anything other than one particular body shape. This means that a male Romano-British skeleton may have a body shape that approximates the sample from which the Korean war ‘Black’ male equations were drawn (Trotter and Gleser 1958). For British archaeological contexts, ‘White’ equations should not be used automatically without critical evaluation. Mays (2016, supporting information table 3) has recently proposed new stature equations derived from the Wharram Percy assemblage. It is therefore imperative always to state which equation has been used for stature estimation. Furthermore, as noted repeatedly, computing a mean predicted stature from the results of a series of prediction equations is statistically invalid and therefore absolutely should not be undertaken. For good statistical analyses, raw long-bone measurements provide better mechanisms for comparisons as these have fewer associated errors, so it is recommended that raw long-bone length measurement data (for each individual) is made publically accessible as a matter of course.

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11 Guidance on recording palaeopathology (abnormal variation)

Charlotte Roberts

Due to the constraints imposed in providing a full revision, a much longer extended document, along with a full bibliography and more images, have been provided at: http://dro.dur.ac.uk/6160*, or can be sent as a pdf (contact c.a.roberts@durham.ac.uk).* I have taken key points from the longer document for this shorter document.

Please also note that this guidance is relevant to osteologists applying for Practitioner or Associate membership of the CIfA (Chartered Institute for Archaeologists); see:
https://www.archaeologists.net/sites/default/files/Osteology%20specialist%20competence%20matrix_final_0.pdf

11.1 Introduction

Palaeopathology is the study of evidence of disease in the bones and teeth of archaeological skeletons and the soft tissues of preserved bodies, but disease can also be reflected in the discovery of parasite eggs found with bodies, in soils of graves containing skeletons, and also in archaeological contexts such as latrines and cesspits.

In general, the quality and quantity of data recorded still varies considerably across the sector (Larsen 2015, 2) and remains a complex, debated and developing issue in bioarchaeology.

11.2 Recording of pathological lesions (see Ortner 2003)

The following lists the main points from the long version of this chapter and reflects the most recent advances in palaeopathology.

Four key methods are used: macroscopic, radiological, histological and biomolecular. Most people use the macroscopic method, and sometimes with radiology (in a commercial and an academic environment). Histological and biomolecular methods are used less frequently, because of costs and access to facilities. Useful references for these methods include Turner-Walker and Mays (2008), Mays (2008a), and Brown and Brown (2010).

It is recommended that preservation of the skeleton should be recorded first (this has implications for what pathological conditions may be recorded/whether distribution patterns can be documented).

Comparison of abnormal with normal bone and dental elements is a pre-requisite to recognising the abnormal, as is access to a disarticulated comparative skeleton and excellent knowledge of the normal appearance of the bones/teeth.

It is recommended that *definite* abnormalities that are not the result of what can be normal variation, pseudopathology, or postmortem damage should be recorded.

Use clinical data as a base to understand the bone changes, but remember that it may not always be appropriate (Mays 2012). For example, a commonly used text is Resnick's *Diagnosis of Bone and Joint Disorders* (latest edition: 2002).

Detailed clear and objective descriptions of pathological lesions are essential (and should be made available for future use, being archived electronically for download). Those descriptions should be used with clinical data to produce differential diagnoses. Consult the following website for terms: https://paleopathology-association.wildapricot.org/Nomenclature-in-Paleopathology. Pathological lesions should also be illustrated with photographs and illustrations, as appropriate.

Palaeopathological and clinical texts usually illustrate the most chronic/severe expressions of disease. However, chronic skeletal lesions do not develop 'overnight'; they may progress perhaps over several months or years. The timing and extent of development of lesions will also vary between individuals for a variety of reasons, such as immune system strength.

There have been recent developments for diagnosis, for example extracting microbial ancient DNA (eg, see Salo et al 1994; Müller et al 2014, Schuenemann et al 2013, Bos et al 2011), despite methodological problems (see Brown and Brown 2010); disease-specific proteins and other biomolecules (eg, mycolic acids) have also been used to diagnose disease. However, positive results for aDNA of a pathogen does not necessarily mean that that the disease caused the bone changes. Relatively recent developments include: looking at strains of pathogens, susceptibility and resistance genes, and diagnosis of disease that only affects the soft tissues.

Sampling for biomolecules for disease diagnosis should only be done when a full skeletal analysis has been done, and the questions being asked cannot be answered in any other way (see also Chapter 13, and https://historicengland.org.uk/images-books/publications/science-and-dead/).

Recording the 'severity' of dental or skeletal changes in disease needs reflection. What do the different grades mean? If recorded, then intra- and inter-observer error tests are needed, at least, to ensure recording consistency within and between observers. Greater 'severity' of bone changes does not necessarily correlate with worse symptoms (eg, see Riddle et al 1988). Recording presence or absence is a safer route to follow.

The updates below refer to the sections used in the 2004 version of this chapter:

11.7.1 Infectious disease

Non-specific infection: infections potentially caused by a range of organisms that cannot usually be identified; *Specific infection* (where the causative organism is known; this might be a bacteria, fungus, virus, or parasite).

11.7.2 Trauma

See Bennike (2008) and Lovell (2008) for updated references on recording trauma.

11.7.3 Joint disease

Only diagnose osteoarthritis (OA) if eburnation exists or, if not, two other bone changes (eg, porosity and osteophytes). Osteophytes alone may indicate the ageing process and should not be used for an OA diagnosis. The different joint disease lesions should not be 'lumped' together to indicate severity; an increase in the extent of one lesion may not necessarily be paralleled by an increase in extent of another.

11.7.4 Metabolic disease

Brickley and Ives (2008); Mays (2008b). *Cribra orbitalia* recording: see above regarding 'grades of severity'. O*steoporosis:* see Agarwal and Stout (2003).

11.7.5 Neoplastic disease

(Brothwell 2008, 2012).

11.7.6 Dental disease

(Hillson 2008). See also chapter 3 of this volume (Antoine).

(i) Caries: for severity of grades (if recorded) use Hillson (2001).

(ii) Calculus: see above regarding 'grades of severity'. Note recent advances in analysing dental calculus (Adler et al 2013; Warinner et al 2014).

(iv) Enamel hypoplasia: see the FDI scoring system (Hillson 2005).

(v) Periapical lesions: (Ogden 2008).

11.7.7 Presentation of data and interpretation

It is recommended that the reader consults the longer version of this section.

Summary statistics are recommended (English Heritage 2004). Active (woven) new bone formation indicates the disease or trauma that caused the lesions was active at or around the time of death (perimortem). Usually it is not possible to suggest the cause of death from analysing skeletal remains, only what diseases or trauma the person experienced through their lives – bioarchaeologists record the skeleton of a person at the point of their death. The bones and teeth reflect an accumulation of disease processes throughout that person's life. Wood et al (1992) remains a very important reference for palaeopathology.

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(NB: a much more extensive bibliography can be accessed in the long version of this update)

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12 Recording of interpersonal violent trauma

Louise Loe (MCIfA)

This is a guide to the recording of interpersonal violent trauma in archaeological human bone, with reference to advances that have been made in the last decade.

Here, trauma refers to any injury to the body as the result of an assault, arising in contexts of violence. In osteoarchaeology, this has primarily concerned warfare and conflict, but also massacre, cannibalism, decapitation and scalping. Child, elderly and domestic abuse are more recent areas (see Wheeler et al 2013; Gowland 2016; Redfern 2015). The focus has generally been on injuries caused by objects used as weapons, such as swords, axes, catapults, sling shots and arrows. Less common are weapons of early modern warfare, such as guns and explosive munitions, but these will feature more in the archaeological record in the near future.

Most developments in the analysis of trauma have been within the field of forensic anthropology (eg, Dirkmaat 2012; Passalacqua and Rainwater 2015) and have been facilitated by experimentation. Within this context, a holistic approach is emphasised in which histology, pathology, forensic anthropology, zooarchaeology (in particular, butchery), engineering, ballistics, taphonomy and physics are integrated. For the osteoarchaeologist this approach is also considered to be important. Preferred interpretations should be justified using published literature and descriptions, supported by diagrams, photographs and radiographs, where appropriate. In recent years more sophisticated equipment has been employed in trauma analysis, including computerised tomography (for example, Appleby et al 2015) and reconstructed three-dimensional multi-detector computed tomography (3D MDCT) imagery (for example, Fleming-Farrell et al 2013). In addition, optical surface measurement systems (Bello 2011) are valuable tools, because they facilitate more accurate comparison with weapon profiles.

12.1 Biomechanics

The fundamentals of trauma analysis rest on knowledge of biomechanics, described in several key texts (for example, Symes et al 2012). A recent, important, development is the observation that fractures initiate at the point of impact and radiate away from it (Kroman et al 2011).

12.2 Identification in the human skeleton

Identification requires detailed knowledge of anatomy, pathology/surgery and taphonomy in order to distinguish genuine lesions from changes that may mimic them (pseudo-trauma). Pseudo-trauma includes medical procedures (for example trepanation), bony pathology, skeletal morphology, burning, and animal and environmental activity. For example, healed depressed fractures may be confused with dermoid cysts and should therefore only be counted if they are greater than 0.5cm (Krakowka 2015). Post-mortem modification is particularly difficult to distinguish, current microscopic criteria not always being adequate, especially when flat bones and trabecula-rich bones are involved (Cappella et al 2014).

Indentification in archaeological bone is especially difficult because it is often incomplete, fragmented and taphonomically altered. Thus, classifying lesions according to degrees of probability (‘low’, ‘medium’ and ‘high’) after Schulting and Wysoki (2005) is recommended.

Weapon trauma may not necessarily relate to violence, but can also be accidental. Thus, the location and distribution of lesions and the archaeological/historical context are important (Martin and Harrod 2015).

12.3 Timing

Trauma may be classified as ‘ante-mortem’ (sustained before death) or ‘peri-mortem’ (sustained around the time of death). ‘Post-mortem’ is another term used to describe changes occurring after death. Biologically, considerable overlap exists between all three categories. Use of the term ‘peri-mortem’ in relation to the death event is especially problematic (see Ubelaker 2015), because bone may bear the characteristics of a fresh break long after death. Similarly, fractures may also occur some time before death but not show healing.

Macroscopically, ante-mortem lesions are identified by their healed margins, that is, margins that are remodelled and/or show evidence of healing (active, porous bone; see Barbian and Sledzik 2008). Healing can now be detected less than 48 hours following an injury using histology (de Boer et al 2012).

Macroscopic identification of peri-mortem lesions rests on the principle that bone that has an intact organic matrix ('green bone') will respond differently to bone that has a partial organic matrix ('dry bone' or 'mineralised bone'). Thus, green bone fractures have sharp, smooth or smoothly curved 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, the removal of chips of cortical bone ('spalling') and margins that are usually discoloured, or the same colour as the surrounding bone, may also indicate that a lesion is peri-mortem (see Loe 2016, 350). Taphonomic signatures on surrounding bone surfaces and, for long bones, fracture margin texture, fracture angle and fracture outline are other criteria (Loe, 2016).

12.4 Causal force and mechanism

Traditionally, injuries are divided into three main categories – sharp force, blunt force and projectile trauma – after Spitz (1980) (Figure 12.1).

12.4.1 Sharp force trauma

Injuries that cut and divide tissue are classified as sharp force trauma and are caused by instruments with acute edged blades ('edge bevel'; see Symes et al 2012) that produce cut/incision, stab, or cleft/notch wounds.

12.4.2 Blunt force trauma

Blunt force trauma typically results in focal or penetrating injuries that have discrete patterns. These can appear as areas of crushing with few distinctive features, or sometimes bear characteristic hallmarks of a particular type of weapon. For more criteria see Wedel and Galloway (2014).

12.4.3 Projectile trauma

Projectile trauma refers to characteristic changes caused by objects (for example, bullets, arrows and spears) that travel through the air with enough velocity to impact bone. Characteristics of projectile trauma on bone have been described with reference to bullets from firearms, although more recently other types have been considered by Kimmerle and Baraybar (2008) who include differential diagnoses (for example, bullets versus shrapnel).

12.4.4 Other types of weapon trauma

Trauma resulting from explosive munitions may be identified by multiple, extensive, comminuted fractures, an absence of fractures associated with a point of impact, decapitation, amputation, penetrating wounds, embedded fragments of bone and/or metal and/or debris, blunt force injuries, acceleration and deceleration injuries and burns (see Browner et al 2015; Ramasamy et al 2010).

12.5 Instrument

It is not always possible to identify the weapon involved, in particular the class of weapon, because of the plasticity of bone and equifinality. Distinguishing blunt falls from blunt force homicidal blows may be explored using multiple criteria, for example, the hat-brim line rule, side lateralisation of fractures and number of lacerations (Kremer and Sauvageau 2009; Guyomarc'h et al 2010). Other work has examined the characteristics of specific weapons (for example, Lewis 2008; Rickman and Smith 2014).

12.6 Number, direction, position and sequencing of wounds

These aspects are often ambiguous because of bone loss from the trauma itself, overlapping wounds, the context of the injury (eg, formalised fighting versus an adventitious assault), taphonomic damage and incomplete preservation.

Figure 12.1 Top: Peri-mortem sharp force trauma to the inferior mandible (bladed weapon trauma; Ridgeway Hill Viking age mass grave, Dorset). Bottom left and middle: Peri-mortem projectile trauma to the left femur (Shrapnel ball injury; First World War mass grave, Northern France, 1916). Bottom right: Ante-mortem blunt force depressed fracture on the lateral, superior aspect of the left parietal, approximately 12mm in diameter (18th/19th century, Radcliffe Hospital burial ground, Oxford). Copyright Oxford Archaeology

A minimum number of injuries may be explored after Kimmerle and Baraybar (2008, 157). Direction may be explored based on the principle that entry wounds are usually larger than exit wounds (Byers 2005, 348). The location and angle of lesions, as well as the appearance of their margins, are other criteria. Estimating sequence follows Puppe's law and requires analysis of intersecting fracture lines (see Symes et al 2012, 362).

12.7 Conclusion

Analysing interpersonal trauma is one of the most challenging and rapidly advancing fields in osteoarchaeology. Recent advances have refined diagnostic criteria and methodologies, have furthered understanding of the biomechanics of fracture, and have introduced new scanning applications. Publications on trauma arising in recent contexts of armed abuse and conflict (Kimmerle and Baraybar 2008), bioarchaeological syntheses (for example, Knüsel and Smith 2014; Martin and Harrod 2015) and experimental work are other trends.

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13 Sampling guidelines for bone chemistry

Mike Richards

Since the 2004 publication of 'Sampling procedures for bone chemistry', there have been a number of significant advances in bone chemistry, particularly in the fields of ancient DNA and protein analysis. For isotope analysis and radiocarbon dating the sample sizes and protocols remain much the same. The comprehensive English Heritage document *Science and the Dead: A Guideline for the Destructive Sampling of Archaeological Human Remains for Scientific Analysis* (Mays et al, 2013) provides an excellent overview of the recent publications and protocols for sampling for isotope analysis and radiocarbon dating, as well as an update on ancient DNA research.

For isotopic analysis, incremental analysis of teeth has become an increasingly popular research area as the sample sizes required for isotope analysis decrease (eg, Montgomery et al 2013). In addition, new isotope systems are beginning to be used. These include the measurement of hydrogen in bone collagen (Reynard and Hedges 2008) as well as the measurement of zinc isotopes in teeth as dietary indicator (Jaouen et al 2016a,b). And more studies have been undertaken exploring the use of isotope analysis in palaeopathology (Richards and Montgomery 2012).

For ancient DNA analysis specifically, there are two main significant advances in ancient DNA studies since the 2004 publication (Hagelberg et al 2015). The first of these is the ability to now sequence large sections of the genome (so called 'next-gen' sequencing) allowing more comprehensive coverage of mitochondrial DNA and opening up the use of nuclear DNA for analysis (Hofreiter et al 2015). The second is the widespread use of population genetics tools for ancient DNA, which is used to infer past population structure and changes, including for humans (Orlando and Cooper 2014). These advances have now made the sequencing of human DNA less prone to error and contamination (although this still remains a significant problem) and detailed pathogen DNA studies are now possible (Wilbur and Stone 2012). The preferred element for sampling for DNA now is the petrous bone, which often contains more DNA than other elements that are commonly sampled, such as teeth (Hansen et al 2017). These advances are also discussed in the English Heritage *Science and the Dead* document, which has protocols for sampling ancient DNA.

In addition, there is a new method of sequencing ancient proteins that survive in bones, and this has started to be used as a phylogenetic tool (Cappellini et al 2014) and as a tool for identifying the species of fragmentary bone recovered from archaeological sites. The technique, developed largely by Matthew Collins at York University, has been coined 'ZooMS' (van Doorn 2014). This tool provides a relatively fast and cheap method of identifying the species of animal (mostly for mammals) and is therefore of most use in zooarchaeology. However, it can also be used to identify human remains, so is of potential interest to human osteoarchaeology. Sample sizes needed for this method are smaller than for other methods (ie, a few milligrams), and the method is designed to be used for rapid screening of fragmentary bones.

Finally, the biomolecular analysis of DNA and proteins preserved in dental calculus is an exciting new area of research (Weyrich et al 2015; Warriner et al 2012). Sampling protocols vary, but usually only require quite small amounts (eg, less than 5mg) of dental calculus.

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14 Sampling human remains for evidence of intestinal parasites

Piers D Mitchell

14.1 Introduction

In recent years there has been growing success with the detection of intestinal parasite eggs in skeletonised burials. For this reason, a new chapter on this topic has been added to the guidelines. While there is not yet capacity among specialists for such analyses to be routine for every excavation, when performed it does provide evidence for past disease that cannot otherwise be detected. Analysis may be best applied to samples of special interest due to their representing a distinct and interesting subset of the population based upon their lifestyle, occupation, diet, religion, place of habitation, or time period in which they lived.

When an individual dies and is buried in the soil, the soft tissues decompose over the following months. The intestines are located in the pelvis and abdomen, and their contents will be released into the soil as they break down. If there are intestinal parasites present, the worms (helminths) die once the host dies, and soil organisms consume them. However, the eggs of intestinal parasitic worms often have a tough, chitinous cell wall that prevents their decomposition by soil bacteria and fungi. The eggs themselves will become unviable after a year or two in the soil, so do not pose any risk of infecting the archaeologist who excavates the burial (Jensen et al 2008). Study of ancient parasites is helpful as it not only helps us determine patterns of disease in past populations, but can also enable us to understand the evolutionary spread of infectious diseases, the levels of sanitation in past communities, the components of ancient diet, provide evidence for migrations, and sometimes indicate occupational activities (Mitchell 2013; Mitchell 2017).

14.2 Choosing a sampling strategy

A number of research groups around the world have a particular interest in the study of ancient parasites (for details, see Mitchell 2015a). It is recommended that a collaboration is set up early to ensure large numbers of samples are not collected without a plan to study them. It is sensible to discuss your sampling strategy with one of these labs before you undertake an excavation, in order to ensure an optimal sampling regime is employed. The sampling strategy will depend upon the research questions of interest, and these questions will themselves depend upon the time period when the individuals lived and their social context. If planning to sample skeletonised burials, it is best to sample at least 50 if sufficient burials are available. This is because only a minority of individuals may be positive on analysis (sometimes 5–20%). Not everyone in the past suffered with intestinal parasites, some soil conditions preserve eggs better than others, and some who were infected in life may have had the eggs washed away over the centuries by rainwater passing through the soil. Sampling individuals from different burial groups can potentially provide evidence for variation in parasite infection between children and adults, men and women, rich and poor, and those following different religions, where this can be identified.

14.3 How to take the soil samples

The best location for sampling a supine burial for intestinal parasites is to take soil from the anterior aspect of the sacrum, and from the sacral foramina (Fugassa et al 2008; Le Bailly et al 2006; Mitchell et al 2013). This is because the contents of the decomposed intestines will move posteriorly over time due to gravity. The amount of soil collected will depend upon the planned research, but for parasite analysis 20g of soil should be ample. If there is interest in undertaking analysis of pollen and other plant materials to assess diet (Reinhard et al 1992; Campbell et al 2011), then larger samples would be required. The samples can be taken with a clean spoon, which should be thoroughly washed between each sample. Photographs of the sample location are helpful to those subsequently analysing the samples. The sample should then be placed in a clear, plastic bag that seals with a zip, with details of the sample written on the outside in permanent pen. It is important to record the burial from which the samples were taken, and the exact location from where the samples were taken. To minimise the risk of leakage of soil, place the first sealed bag in another bag. The details of the sample can also be written on a piece of paper placed between the outer and inner bag so that if the pen wears off the inner bag (for example, if the pen used was not a permanent marker) the details are not lost.

In some burial contexts, intact coprolites may be found in the abdominal and pelvic area. Coprolites are preserved pieces of faecal material that maintain the shape of the original stool (Bryant and Dean 2006). They may be mineralised, where soil minerals are absorbed into the coprolite and harden it, or waterlogged where they are immersed in wet soil. On occasions, the position of the ascending, transverse and descending colon at death can be seen from the location of a string of coprolites (Rácz et al 2015).

In some regions partially or fully mummified bodies may be found in archaeological contexts (Lynnerup 2007). In these contexts, faeces can be extracted directly from the intestines. In the case of fully mummified bodies, samples can be obtained by passing sampling instruments internally via the anus.

14.4 Control samples

Control samples are needed to compare with the pelvic soil samples in order to detect evidence for the generalised contamination of soil by parasite eggs and faeces. These controls are taken from regions of the body where we would not expect to find intestinal contents, and soil from the feet and inside the skull are recommended (Reinhard et al 1992). At certain times in human history (such as the medieval period) it was common to discard human faeces in the streets, on open ground, or on farmland to act as a crop fertiliser (Mitchell 2015b). If the dead were buried in soil already contaminated with human faeces, then soil in the pelvis at the time of excavation may potentially include soil thrown onto the corpse at the time of the burial. Parasite eggs found in pelvic soil in such a scenario might be from the deceased individual, or from the contaminated burial soil. If there is generalised soil contamination, then parasite eggs will be found in the control samples of soil from inside the skull and by the feet. However, if these control samples are negative for parasite eggs, and if the pelvic soil is positive for eggs, this would indicate a genuine infection with intestinal parasites at the time the individual died (Mitchell et al 2013).

14.5 Storage

The samples should be stored in a cool dark place, with minimal temperature fluctuations. There does not appear to be any benefit from refrigeration or freezing of samples, as archaeological soil has already been above freezing temperature for centuries, and any material prone to decomposition will have already done so. We have had no problems when undertaking ancient DNA analysis of soil samples that were not frozen or refrigerated after their excavation. The plastic bags from each site can be stored in large plastic boxes with fastening lids, to provide some protection against water dripping from above, or flooding that may potentially affect basement storerooms.

14.6 Analysis

Ancient faecal material can be analysed with microscopy, Enzyme-Linked Imunosorbent Assay (ELISA) or aDNA sequencing (Anastasiou and Mitchell 2013a; Côté et al 2016; Dittmar 2009). In order to undertake microscopy or ELISA, the solid soil needs to be made into a liquid suspension, a process known as disaggregation (Anastasiou and Mitchell 2013b). Then the parasite eggs are separated from the bulk of the soil using methods such as sedimentation, flotation, or passing through a stack of microsieves of decreasing mesh sizes (Araújo et al 2015; Reinhard et al 1986; Warnock and Reinhard 1992). This parasite concentrate can be mixed with glycerol or other suitable mounting medium, and viewed under high power light microscope at x400 magnification. Identification of parasite species is made by considering the shape, dimensions, colour and special characteristics of each egg visualised (Figure 14.1).

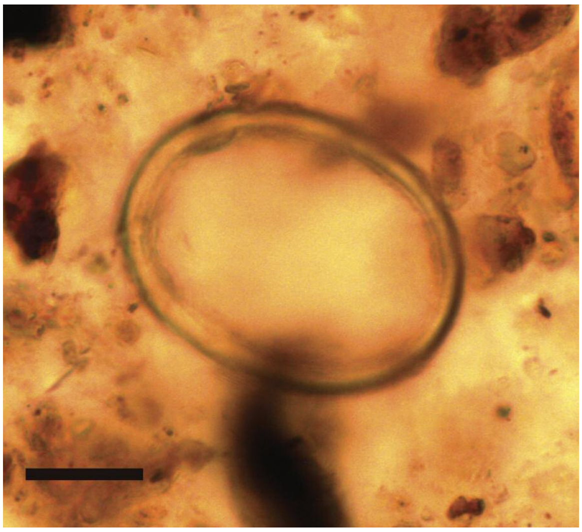

Figure 14.1 Decorticated roundworm egg from the pelvic soil of King Richard III (died 1485 AD). Egg dimensions 62 x 45µm. Black scale bar indicates 20µm. Image: Piers D Mitchell

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15 After the osteological report: the long-term fate of skeletal collections

Simon Mays

The purpose of an osteological report on a skeletal assemblage compiled at the analytical phase of a fieldwork project on an archaeological site is to:

- shed light on research questions pertinent to the skeletal remains, the site from which they come, and the region in which it is situated
- make osteological data available to the wider scientific community
- alert other researchers to the existence of the material
- act as a guide for researchers wishing to study the material.

The main rationale for the report is the first of these. Focusing osteological reports towards important research questions helps to ensure the centrality of study of human remains within reports on excavations of cemetery sites, and helps increase the influence of osteoarchaeology within archaeology as a whole.

Important though the osteological report is, it must be remembered that no report, however carefully prepared, can substitute for the long-term retention of the skeletal material itself, and in any event this is not its purpose. It is impossible for an osteologist writing a bone report to predict what information future researchers, working on research projects as yet unformulated, might require. Therefore, the chances of a bone report containing precisely the data that a researcher needs for his or her research project are minor. Although osteological reports form a useful basis for some synthetic and comparative work, almost all serious, problem-orientated research in osteoarchaeology involves examination of the skeletal material itself (Mays, 2010). Most scientific work on important collections is usually carried out after the publication of the site report. This is because the appearance of the bone report publicises the existence of the collection and stimulates interest in it among researchers, who then bring their own research agendas and techniques to bear upon the material. In addition, a good osteological report, and the data on which it is based, helps researchers to determine if the collection is likely to be useful for their research, and helps them identify specific subsets of the material that may be of interest to them.

Changes in theoretical orientations of academic disciplines mean that new questions continue to be asked of archived remains, and methodological innovations enable new information to be obtained from old collections. Most well-excavated collections of skeletal remains have research potential beyond that realised in the initial study that forms part of the site report, and so museum collections are returned to time and again. In a scientific discipline, it is vital that future workers should be able to check the observations of earlier researchers so that errors and deficiencies may be remedied. Only the retention of the physical evidence, in the form of skeletal material, permits osteoarchaeology to retain this ability to be self-correcting, something that is a fundamental requirement of a scientific discipline.

The UK is currently a world leader in osteoarchaeological research, and the most important manifestation of this is the high-profile contribution of UK-based workers to the international scientific literature. Research published in international scientific journals is almost entirely based on examination of curated skeletal collections (Mays, 2010). Important collections (often the larger, well-documented assemblages) are heavily used (Roberts and Mays, 2011). Although large collections of remains are space-hungry, the intensity of research conducted on them makes a powerful case for their long-term retention.

I have sometimes heard it claimed that skeletal material which has been reburied can always be re-excavated if it is needed by future researchers. In fact, reburial of human remains beneath the soil or in structures (such as vaults) where environmental conditions are uncontrolled results in their severe deterioration (During 1997). In addition, any context labels that might have been interred with the remains may deteriorate and become illegible, divorcing the skeletal remains from the archaeological context data that would be needed for their study. This, together with the logistical and financial implications of re-excavating reinterred material, means that, in practice, once remains are reburied there is permanent loss of scientific information.

Currently in England, the secular burial laws are permissive toward retention of archaeological human remains long-term in museums or equivalent institutions, and public opinion is generally supportive of this (Mills and Tranter, 2010). The UK lacks the activism towards wholesale reburial of human skeletons in museum collections that has been such a feature in, for example, North America. Although routine reburial of UK collections would be out of kilter with public attitudes, in specific cases, public opinion, particularly local public opinion, may favour reburial of remains, and in such cases this clearly needs to be taken into account when making decisions on the fate of a collection.

Ecclesiastical law controls the excavation of burials from land under Church of England jurisdiction (in practice usually churches or churchyards in current use). Faculties issued by the Church of England for excavation of burials generally stipulate reburial of remains, normally after some period during which scientific study is permitted. When this is the case, there is a tension between the desirability of retention of remains for research and a desire to see them returned to consecrated ground. In 2005, a working group convened by English Heritage (now Historic England) and the Church of England suggested that deposition of remains in unused church buildings (which, theologically speaking, remain consecrated) might be one solution (Mays, 2017). This would allow material to be retained in consecrated areas but at the same time it would continue to be available for study by *bona fide* scientific researchers. This practice has been implemented in some cases (Mays, 2013), and it should be borne in mind as a possibility when important collections of material are faced with the prospect of reburial. Failing this, efforts should be made, for important collections excavated under Church Faculty, to negotiate a reasonable time interval (perhaps ten years) between the publication of the skeletal report and reinterment, and (when it can be justified) to argue for renewal of the Faculty when it expires to avoid curtailment of scientific research by premature reburial.

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Other online resources

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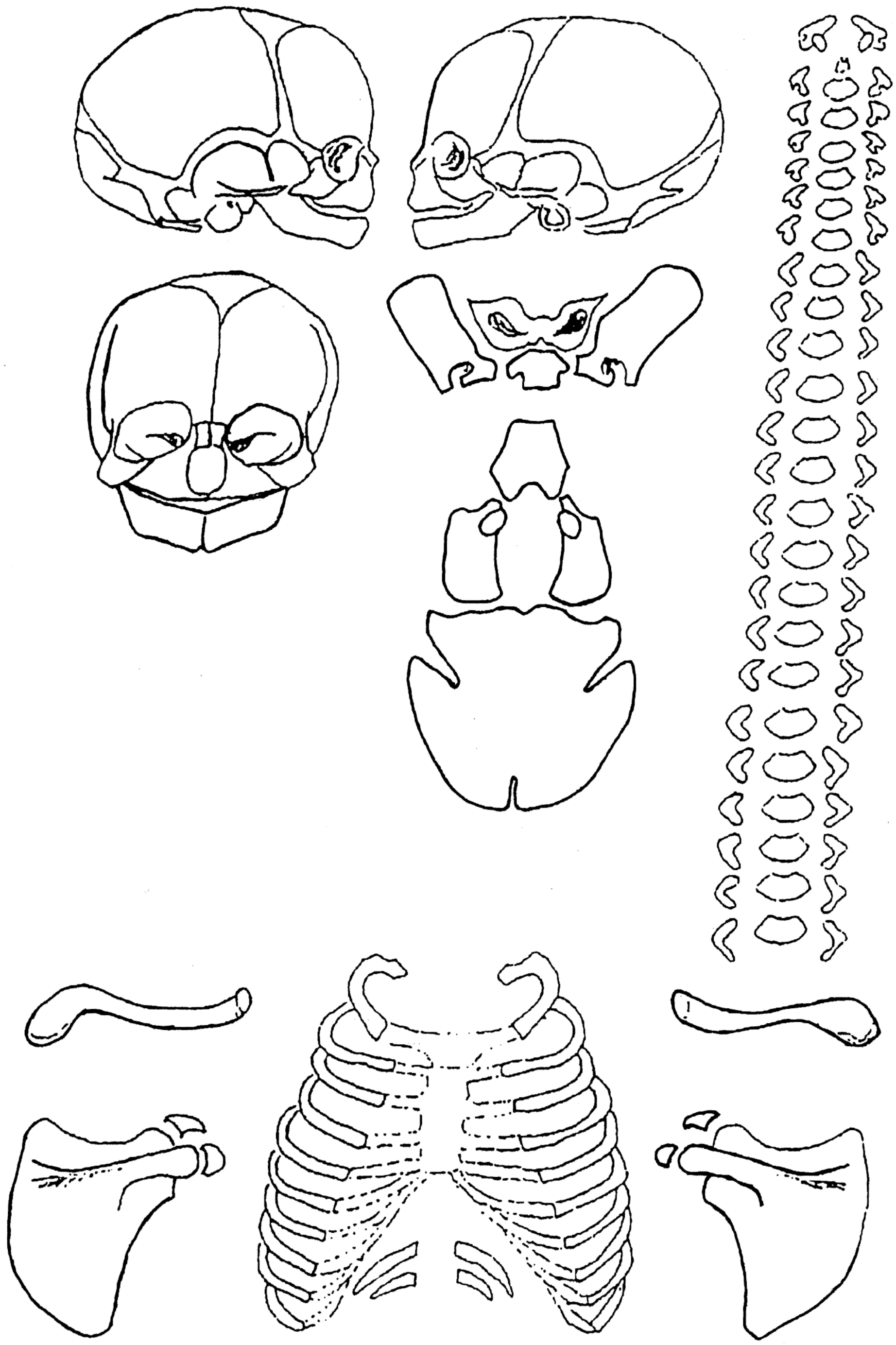
Sources of advice

Casework advice for professionals regarding issues associated with the retention, curation or reburial of archaeological human remains in England is available from The Advisory Panel on the Archaeology of Burials in England (APABE) (http://www.archaeologyuk.org/apabe/), and from the Museums Human Remains Subject Specialist Network (http://www.humanremains.specialistnetwork.org.uk/)

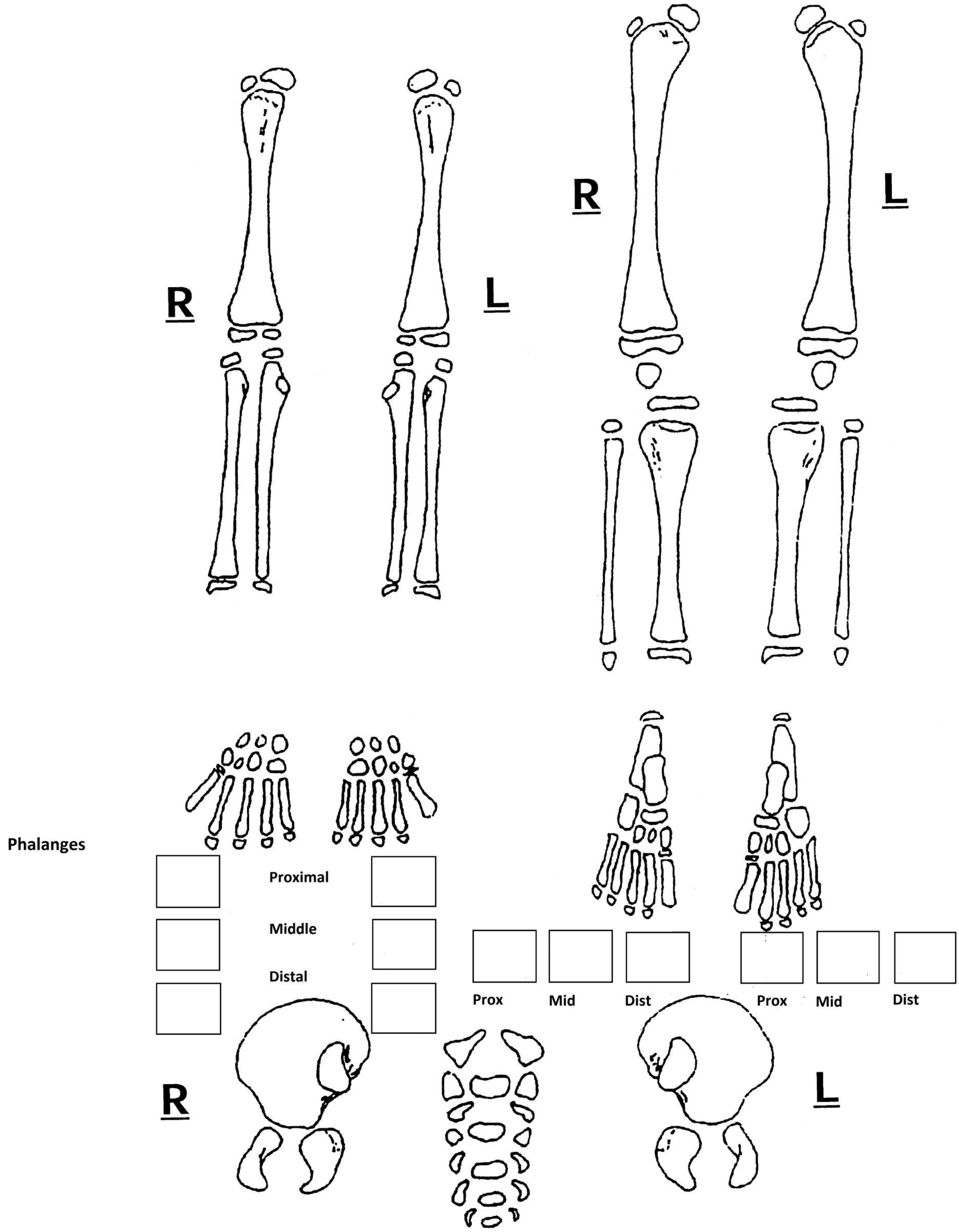
Appendix 1a

Recording sheet for infant human remains



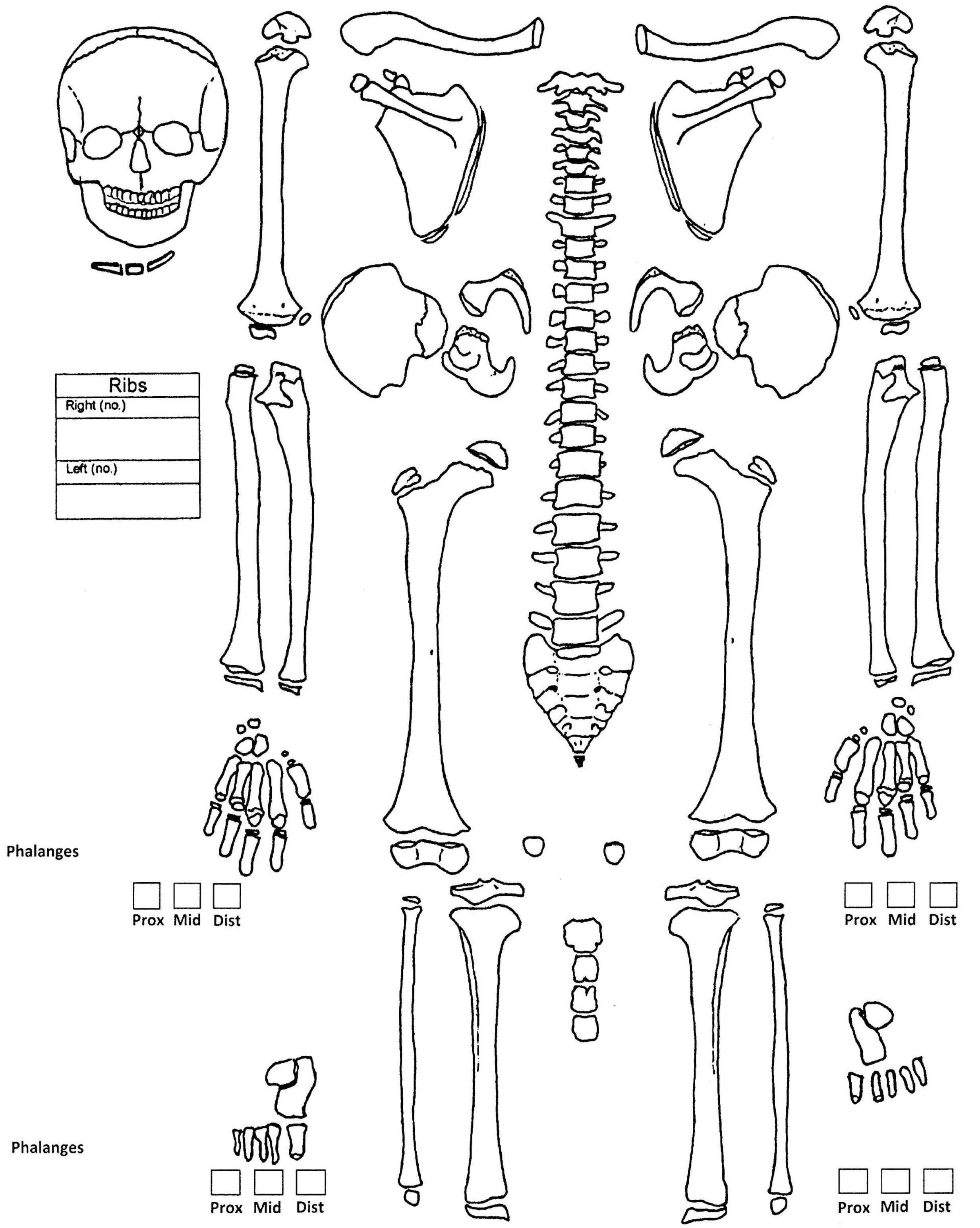
Appendix 1b

Recording sheet for infant human remains



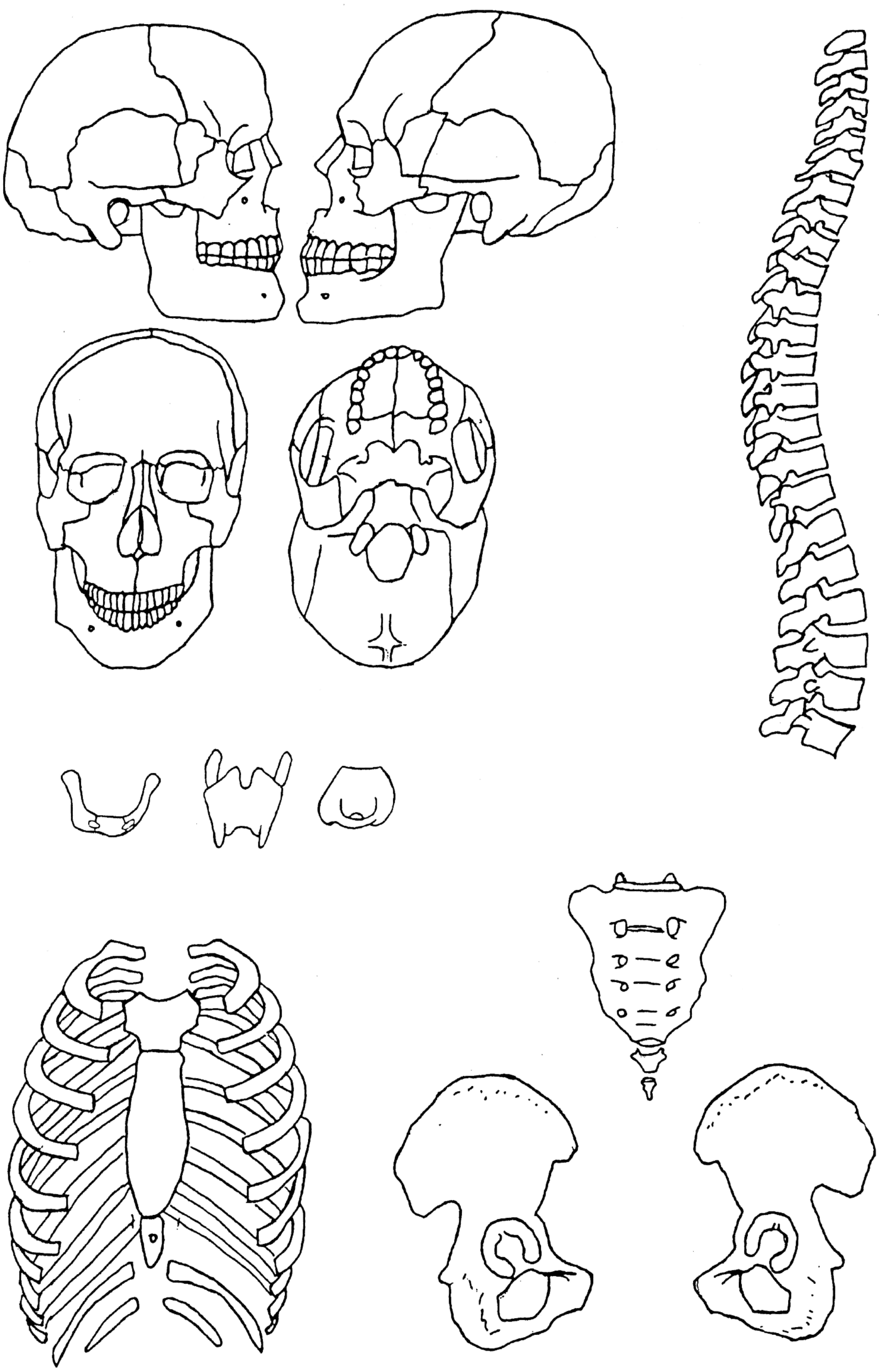
Appendix 2

Recording sheet for juvenile human remains



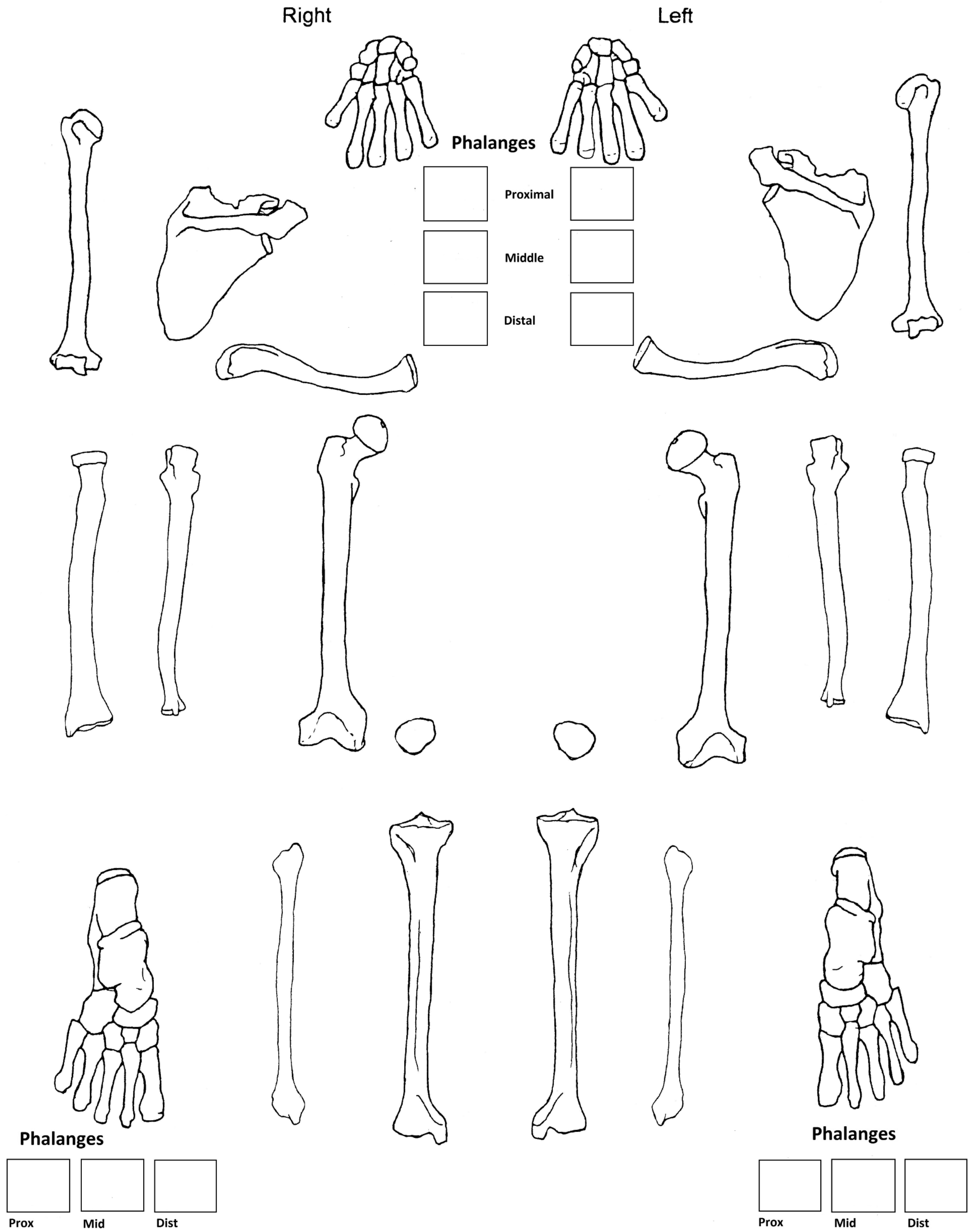
Appendix 3a

Recording sheet for adult skeletal remains



Appendix 3b

Recording sheet for adult skeletal remains



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