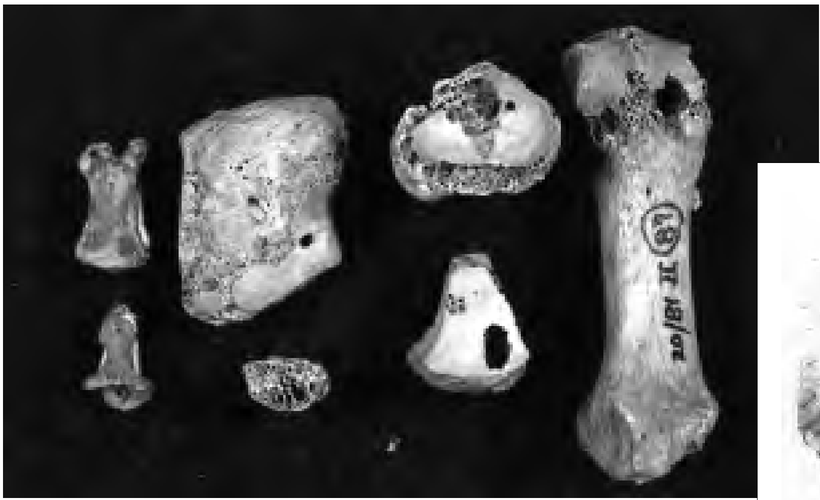
# Guidelines to the Standards for Recording Human Remains

## IFA Paper No. 7



**Editors: Megan Brickley and Jacqueline I McKinley**

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**BRITISH ASSOCIATION FOR BIOLOGICAL ANTHROPOLOGY AND OSTEOARCHAEOLOGY**

**INSTITUTE OF FIELD ARCHAEOLOGISTS**

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## The contributors

*Anthea Boylston*
Anthea has been undertaking contract work in human remains from archaeological sites for the past 13 years, working for archaeological units nationwide on collections dating from the prehistoric to post-medieval. She was involved in the excavation and post-excavation analysis of the first mass grave from a known battle to be found in Britain over the last century (Towton, Yorkshire). This resulted in a multidisciplinary study in collaboration with staff from the Royal Armouries. She recently participated in a project collaborating with the curatorial staff of the Norton Priory museum and gardens linking evidence of disease on the skeleton with the medicinal plants utilised for treatment in the medieval period. Since completing her Master's Degree at the University of Bradford in 1991 Anthea has participated in undergraduate and postgraduate teaching in the Department of Archaeological Sciences and in instructing palaeopathologist from all over the world on the short courses held in the Biological Anthropology Research Centre laboratory.

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Megan Brickley obtained her PhD from the University of London in 1998, her research being undertaken jointly between the Institute of Archaeology and the Hard Tissue Research Unit, University College London. In 1997 Megan was appointed lecturer in Environmental Archaeology at the University of Birmingham where she teaches on all aspects of human bone from human origins to forensic anthropology. Her main research interests lie in investigations of metabolic bone diseases, but since working at Birmingham she has also undertaken contract work on human bone with the Birmingham University Field Archaeology Unit (now Birmingham Archaeology). She is currently writing up the report on the eighteenth / nineteenth century human bone from St Martin's, Birmingham.

*Don Brothwell*
Don Brothwell is an art school drop-out who became hooked on skeletal studies. He taught this and other subjects at London, Cambridge and York. Not being ageist, he still teaches and researches, but doesn't have to attend boring meetings anymore. In his life, he has been checked for venereal disease, and has had pubic lice, various worms and septic jigger fleas, as well as various respectable conditions and skeletal traumas; vertebral osteophytes now cause him some problems. He bitterly regrets that the repression of western morality has seriously impeded the spread of his DNA into the next generation. He is currently working on further publications, if Alzheimer will leave him in peace.

*Brian Connell*
Brian completed his HND in Practical Archaeology at Bournemouth University in 1992 and went on to study his MSc in Osteology, Palaeopathology and Funerary Archaeology at Sheffield and Bradford in 1993. Subsequently he has worked in contracting archaeology, first at the Calvin Wells Laboratory for the University of Bradford, then as a zooarchaeologist at the Ancient Monuments Laboratory for English Heritage. In 1998 he returned to human bones when he began working on human bone assemblages for MoLAS. He is currently the lead human osteologist on the Spitalfields Market Project. His research interests include palaeopathology and physical anthropology.

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Graduating in 1981 (Archaeological Sciences, Bradford University), as archaeologist Jacqueline has worked on a wide-range of excavations, and as osteoarchaeologist has analysed and reported on the remains of over 6000 cremation and inhumation burials from over 300 sites, ranging from Neolithic to Post-mediaeval across the British Isles. A regular visiting lecturer (on cremation) at several English universities, she has also occasionally worked on forensic cases in the UK and elsewhere. Currently employed by Wessex Archaeology as a senior project officer, over the last ten years her time had been divided between managing, running and writing-up archaeological excavations, and the analysis of human remains from both Wessex Archaeology sites and those of other archaeological organisations nationwide. Her specialist interest lies in the study of the mortuary rite of cremation, and improving site recovery and recording of human remains.

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Simon gained his PhD at the Department of Archaeology, University of Southampton in 1987. In 1988 he joined English Heritage as their human skeletal biologist, a post he still holds. Since 1999 Simon has been a visiting lecturer at the Department of Archaeology, University of Southampton. His research interests cover all areas of human osteoarchaeology, particularly material from the British Isle. Simon is the author of *The archaeology of human bones* (1998, Routledge) and with Margaret Cox co-editor of *Human Osteology in archaeology and forensic science* (2000, Greenwich Medical Media).

*Linda O'Connell*
Dr Linda O'Connell is a lecturer in Forensic and Biological Anthropology at Bournemouth University. She is a qualified medical doctor who has chosen to specialise within the aforementioned field and is extensively involved in the delivery of the three Masters courses (Forensic and Biological Anthropology, Forensic Archaeology and Osteoarchaeology) offered by the Forensic and Bioarchaeological Sciences Group. In addition, she contributes to undergraduate programmes

and is involved in teaching short courses in forensic archaeology and anthropology to the police. Her main research interests include the association between the human pelvis and vertebral degenerative disease, and the evaluation of the effects of modern clinical conditions (and their treatments) upon the human skeleton and how these may facilitate the identification of individuals recovered from forensic contexts. She has written numerous archaeological skeletal reports and is involved in forensic work both locally and further afield.

*Mike Richards*
Mike is a Reader in Bioarchaeology at the Department of Archaeological Sciences at the University of Bradford. He obtained his DPhil from the Research Laboratory for Archaeology and the History of Art at the University of Oxford in 1998, and a BA and MA from the Department of Archaeology, Simon Fraser University, Canada in 1992 and 1994. He specialises in bioarchaeology, particularly in bone chemical studies, such as stable isotope studies of past human diets.

*Charlotte Roberts*
Reader in Archaeology, Department of Archaeology, University of Durham since 2000, teaching undergraduate and postgraduate students. Charlotte began her career as a State Registered Nurse, subsequently gaining a BA Archaeological Studies (Leicester), MA Environmental Archaeology (Sheffield), and PhD in Biological Anthropology in 1988 (Bradford). Charlotte has published *c.* 100 papers, four senior authored books, and two edited books; most recently (2003) *Health and disease in Britain: prehistory to the present day* (with M Cox), and *The bioarchaeology of tuberculosis: a global perspective on a re-emerging disease* (with J Buikstra).

*Sonia Zakrzewski*
Sonia obtained her PhD in Biological Anthropology at University of Cambridge. Following an Addison Wheeler Research Fellowship in Archaeology at the University of Durham, she now lectures in biological anthropology and human osteology in the Department of Archaeology, University of Southampton, where she is the course convenor for the MA in Osteoarchaeology. Her main research interests are in morphological population variation in relation to human evolution. Her research has primarily focused on the population affinities and morphological diversity within a variety of regions, including Egypt, the Caribbean and Britain. She has also been looking at changes in social identity and sexual dimorphism within a variety of Northeast African groups.

# 1 Introduction

*Megan Brickley*

Since the founding of the British Association for Biological Anthropology and Osteoarchaeology (BABAO) in 1998, the issue of standards in recording of human skeletal remains in Britain has been of concern to the membership. The need for a guidance document to give specialists a framework within which to work was outlined at the annual meeting of the association held at Durham University in 2001. Recording of human bone is one of the few areas of a project over which the specialist has control and they are anxious to achieve a high level of professionalism. Standardised recording will enable greater comparability between human bone assemblages from different sites. The difficulties currently encountered in making comparisons between skeletal reports have recently been highlighted by Roberts and Cox (2003) in their attempt to study health and disease in Britain from prehistory to the present day. Comparisons are required for all levels of work, from standard bone reports where comparative data is required to set an assemblage in its wider context (Mays *et al* 2002), to doctoral research where data are needed to aid decisions on inclusion of skeletal remains in an investigation.

This document is primarily aimed at those engaged in the recording of human bone from commercial projects. Recording undertaken to answer questions relating to specific areas of research pertaining to a site (eg obstetrics and parturition at Christchurch Spitalfields; Molleson and Cox 1993) will require greater detail than is outlined in this document. Research carried out as part of specific projects above and beyond the general site report will also be more detailed. It is not the intention to preclude wider research, indeed it may only be through such work that specific archaeological questions can be answered or knowledge of past populations increased. It is also recognised that due to the rapidly changing field of research into human skeletal remains that this document will have a limited lifespan (probably in the region of ten to fifteen years).

The situation pertaining to recording and analysis of human remains in the British context is different to that found in the United States, where a guidance document has already been published (Buikstra and Ubelaker 1994). The differences lie in the former and current cultural and political systems in the USA, which have affected the quantity and type of remains recovered, and have had implications for the commercial and research-based analysis undertaken.

This document should not be viewed as a 'recipe book', but rather as a guide giving advice about the current state of affairs relating to various fields of research and analysis. As there was little point in re-writing significant amounts of information already available, readers are frequently referred to publications where specific details of recording methodology or rationale can already be found. This document aims to provide some basic pointers as to what the recording of different types of information might reveal, and through this assist in devising a research design for any assemblage and provide guidance as to the ways in which questions posed by the archaeologist might feasibly be answered. Many of the areas of investigation covered in the various sections of this document are not mutually exclusive but are interdependent in terms of producing a comprehensive report. A standard record of any assemblage should include an inventory (Sections 2–5), which not only presents a record of the bones which were available for analysis but is essential for the calculation of the prevalence of pathological lesions and conditions; a record of the data used to determine the age and sex of an individual (Sections 6–8); metric data and a record of non-metric traits (Sections 9 and 10), which assist in sexing and are necessary for the calculation of various indices to further our understanding of biodistance within and between populations; and an accurate record of pathological lesions (Sections 11–12).

Other documents which it is advisable to consult include: Garratt-Frost (1992) for guidance relating to the law and human remains; McKinley and Roberts (1993) on the excavation and post-excavation treatment of cremated and inhumed human bone; Cox (2002) on crypt archaeology; the joint English Heritage / BABAO publication *Human Bones from Archaeological Sites: Guidelines for producing Assessment Documents and Analytical Reports* (Mays *et al* 2002) and the IFA's *Standards and guidance for the collection, documentation, conservation and research of archaeological materials* (2001). For those working in Scotland and Northern Ireland other useful documents are available (Historic Scotland 1997; Buckley *et al* 1999).

# 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* (2002) should have been undertaken at the assessment stage. However, for the production of a human bone report exact numbers of individuals present should be calculated (infants may be present with adults that had not been noticed during excavation), and the condition of the bone of each individual should be analysed and recorded (Janaway *et al* 2001, 202–4).

## 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 Section 11.8). Use of visual recording forms such as those included as appendices in this document will allow not only the completeness, but also the amount of fragmentation affecting bones to be recorded. Fragmentation has important implications for the amount of metric data that will be recordable. Systems of recording should be made clear and fully referenced, where necessary, in the final report.

## 2.2 Surface preservation

The surface preservation of bone should be recorded following published guidelines as statements such as 'the bone was well preserved' are almost meaningless and there will be discrepancies in the way different researchers apply and interpret such a statement. This document contains a newly compiled, illustrated set of recording criteria for human bone to allow consistency (Section 5.3.2). 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. 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.

Recording of other types of taphonomic changes are dealt with in more detail in Section 5, dealing with disarticulated and co-mingled human bone.

## 2.3 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.

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 are provided in this document (Appendices 1–5) for those wishing to record greater detail.

## 2.4 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 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. 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 (Figure 1) and such illustrations form an 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

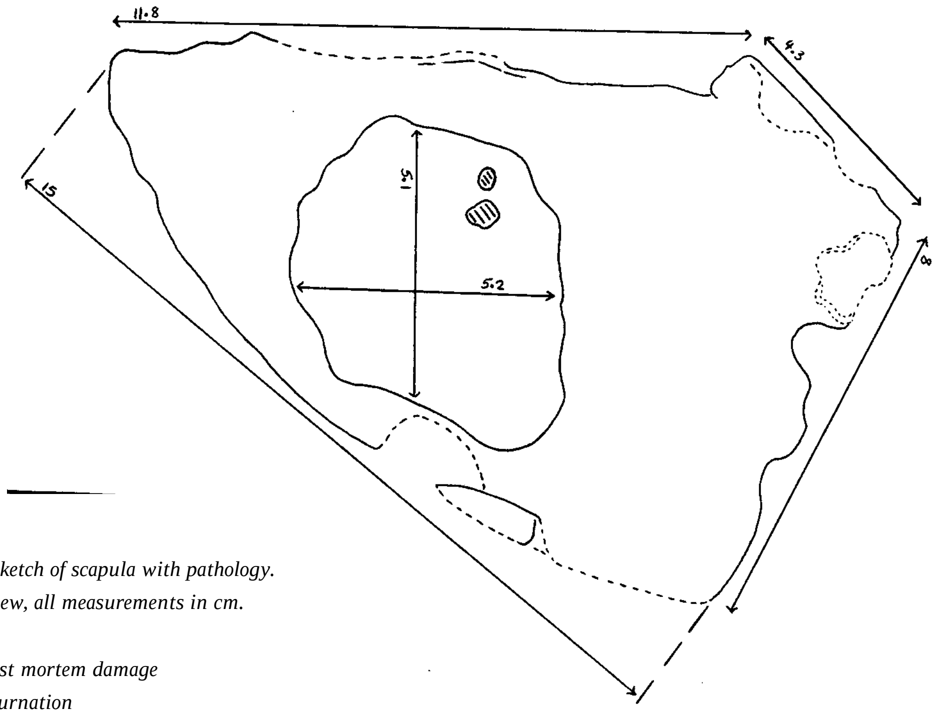



*Figure 1 Sketch of scapula with pathology.*
*Anterior view, all measurements in cm.*
*Key:*
- - - - *post mortem damage*
/// *eburnation*
*(Illustration courtesy of Rachel Ives)*

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 specimens better than a monochrome image. More detailed information on the suitability of different film types for storage in an archive and photographic techniques for different types of bone and teeth is provided by Buikstra and Ubelaker (1994, 10-12). The progressively increasing quality of close-up images from digital cameras render them very useful for taking record shots – particularly where material is to be reburied – since the images are easily and relatively cheaply stored to form part of the archive.

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 microscopy, and it is possible to attach a camera to a microscope with a suitable attachment. At the assessment stage of a project the possibility that either light or scanning electron microscopy 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 and co-workers (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, as well as forming a valuable resource in the archive.

# 3 Compiling a dental inventory

*Brian Connell*

The aim of a dental inventory is to count all of the individual teeth and tooth positions available for examination. This initial quantification allows assessment of how complete the dentition is and permits calculation of the prevalence of dental pathology. In practice it is easy to use the Zsigmondy system (see van Beek 1983, 5) which allows the deciduous or permanent dentition to be recorded using grids (Figures 2 and 3). Each grid is divided into four sections, each of which corresponds to a quadrant of the dentition. The numbers within each quadrant relate to the individual teeth in that section. For example in Figure 2 the top right quadrant labelled A–E represents the left maxillary deciduous teeth, and the lower left section of Figure 3 labelled 8–1 represent the right mandibular permanent teeth.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Right | | | | | | | | | | | Left |
| | E | D | C | B | A | A | B | C | D | E | |
| | E | D | C | B | A | A | B | C | D | E | |
| Right | | | | | | | | | | | Left |

*Figure 2 Recording grid for deciduous dentition*

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Right | | | | | | | | | | | | | | | | | Left |
| | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | |
| | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | |
| Right | | | | | | | | | | | | | | | | | Left |

*Figure 3 Recording grid for permanent dentition*

The only disadvantage of the Zsigmondy system is that an adult may have four teeth with the same number; this presents significant problems when data are being entered into a database. Consequently, it is important to consider how data will be processed and analysed before recording starts. Where data is to be entered into some form of database the system set out in Buikstra and Ubelaker (1994, 14a and 14b) should be implemented. In this system the permanent dentition are numbered 1 to 32 and the deciduous dentition 51 to 70. This system means that each tooth has a unique number making it easier to make a query on pathology by individual tooth. The different numbers for permanent and deciduous teeth also assist in recording and entering data on juveniles with mixed dentition.

The most important aspect of recording information relating to the dentition is to ensure that in both the archive and publication reports the system employed and coding used are adequately referenced and / or explained.

In counting the presence or absence of teeth some distinctions have to be made about ‘absence’ because teeth can be missing for different reasons. For example, a particular tooth can be missing due to post mortem loss (tooth has fallen out of the socket), ante mortem loss (with the socket partially or fully healed) or the tooth could be congenitally absent, ie the tooth did not form in the first place. The following symbols should be used on the grid to record data about the individual teeth or tooth position:

| | |
|---|---|
| \ | scored through the tooth number indicates tooth lost post mortem (this can be difficult to do on a computer so in computerised records the strikethrough effect, found in the font section of the tools menu could be used) |
| - | scored through with a horizontal line indicates tooth present but socket missing |
| x | tooth lost ante mortem |
| np | tooth not present |
| --- | jaw and teeth not present |
| c | caries (cavity) in tooth |
| b | broken tooth |
| a | abscess |
| e | tooth erupting |
| u | tooth unerupted |

Where a tooth is present and has no abnormality the letter, number or other symbol used to represent the tooth should be left with no symbol added. Examples of how to use this type of recording system are provided by Brothwell (1981, 51-54). Dental pathology is covered in Section 11. For details on tooth identification or further details on labelling systems consult Hillson (1996, Table 2.1) or van Beek (1983).

# 4 Compiling a skeletal inventory: cremated human bone

*Jacqueline I McKinley*

## 4.1 Introduction

Cremation was the predominant rite for the disposal of the dead at various phases in Britain's past, from prehistory up to and including the Anglo Saxon period. Consequently, cremated human bone is frequently encountered in archaeological mortuary deposits. The analysis of cremated bone shares many of the aims common within the study of all archaeologically derived human skeletal material (eg demographic and pathological data). Cremated material is the product of a series of ritual formation processes within a mortuary rite, the nuances of which are still little understood. Systematic data collection of a comparative nature is essential if we are to increase our understanding of the geographic, temporal, social and individual variations and similarities within the rite. It is the responsibility of the osteologist to collect and analyse the evidence for pyre technology and ritual reflected in the form and condition of the cremated bone. In all areas of analysis, the context of the deposit comprising or containing the cremated remains is a vital consideration and no recording or analysis should be undertaken without access to the archaeological site records.

## 4.2 Areas of data recovery

The various types of data required to fulfil (as far as possible) the aims of analysis as outlined above may be expressed as a series of questions;

- type of deposit
- level of disturbance / truncation
- total weight of bone (exclusive of extraneous material)
- demographic data
- pathology data
- degree of fragmentation
- efficiency of cremation (ie levels of oxidation and dehydration)
- skeletal elements represented
- presence and type of pyre goods (including staining to bone)
- presence and type of pyre debris
- formation process – undisturbed, spit-excavated deposits

Deposits comprising or containing cremated bone should have been subject to whole-earth recovery in excavation (McKinley 1998; 2000a). The term 'sample' is deliberately avoided as this implies only partial recovery which is not acceptable for cremation-related deposits of any type, other than in rare extreme circumstances (eg lack of access). Unless the osteologist is to personally excavate the remains of an intact urned burial, the cremated bone should have been cleaned prior to receipt via careful wet sieving to 1mm mesh size, and all extraneous material (eg stones and other coarse components) within the residue should have been removed from at least the 5mm fraction and above. In most cremation-related deposits, other than intact urned burials, the quantity of extraneous material ('pea-grits' etc) in the smaller fractions is too great for cost-effective extraction of all the bone and the residues should be scanned to remove fragments of human bone identifiable to skeletal element, animal bone or other pyre goods.

## 4.3 Recording

Analysis can be undertaken in a series of steps which will allow recovery of the data without necessitating repeat handling.

1. Obtain the *total weight of bone* from the combined sieve fraction weights (see Cover, lower Figure). This, together with a measure of the maximum fragment size, will give an assessment of *bone fragmentation*.
2. Examine every fragment of bone, however small, at least once. Identifiable material may be present amongst even the 1mm sieve residue be it human, animal or artefactual in nature.
3. Separate out identifiable bone fragments into four skeletal areas – skull, axial skeleton, upper limb and lower limb – for further detailed analysis. In case of any need to reaccess this 'identifiable' material, it is advisable to bag it separately after recording rather than to re-mix it with the mass of bone from the context. If space allows, this separate bag may be placed within the main bag of material from the context.

### 4.3.1 Type of deposit

No analysis of cremated bone should be undertaken without reference to the context from which it was recovered. The osteologist must have access to the site record sheets – if they are not sent with the bone, ask for them; meaningful analysis cannot be undertaken without the site data. The archaeological records should include a description not just an interpretation of the deposit. All too often record sheets offer the term 'cremation' as an interpretation of the deposit where what is meant is 'cremation burial' – the two are not synonymous. A 'cremation' is a burning pyre, ie part of a mortuary rite. The cremated bone and other remains may be deposited in a 'burial', as 'redeposited pyre debris', or remain *in situ* or be manipulated on the pyre site itself (not to mention various forms of accidentally disturbed and redeposited material; McKinley 1997; 1998; 2000a; 2000b).

There is increasing evidence for apparently deliberate differentiation in cremated material (not necessarily the human bone) recovered from the different types of deposit in some temporal periods (eg Polfer 1993). The various parts of the mortuary rite will only become further apparent through detailed comparison. It must, therefore, be made clear throughout all areas of analysis (eg with a code or statement attached to the relevant context number in any database, archive and publication tables or other records) from what type of deposit the material was derived. Recorded deposit types may include;

- pyre sites – with either *in situ* or manipulated pyre debris (including cremated bone)
- burials – urned: ceramic, glass (Romano-British) or stone (steatite in parts of Scotland) vessels and unurned burials: generally the presence of some form of organic container is apparent or bone may be spread across base of a cist grave (prehistoric)
- redeposited pyre debris – may be in the grave fill, over the grave, in a pre-existing feature (eg ditch) or formal deposit in a deliberately excavated feature
- cenotaph – may contain a small amount of bone (<25g) or none
- cremation-related deposit (ie don't know or unsure of the type) – redeposited bone

Burials, urned and unurned, are the most commonly recovered type of deposit, but there is growing recognition of pyre debris deposits of various forms. More pyre sites are being found and the concept of a cenotaph or memorial is now being recognised archaeologically in association with the cremation rite (McKinley 2000b).

The term 'cremation' should only be applied to the act of burning the body or the mortuary rite, not to the cremated remains or the archaeological deposit.

### 4.3.2 Disturbance

The condition of cremated bone may be affected by the nature of the deposit from which it is recovered, by taphonomic processes including post-depositional disturbance, and by excavation and post-excavation processing (McKinley 1994a). The site record sheets should give reference to the levels of potential truncation and disturbance – if not, ask the excavator, this information is essential. Direct comparisons (weight, bones present etc) cannot be made between disturbed and undisturbed deposits, or between intact and heavily truncated ones. Interpretation requires comparison of 'like with like' and between deposits with different levels of disturbance.

As with the deposit types, a statement or code should be attached to each individual context record within the various databases, tables etc, to distinguish levels of disturbance, in both archive and publication. Levels generally observed may include;

- undisturbed, lidded urned burials – generally very little or no sediment will have infiltrated the burial (the only instance where bone is liable to be of same size as at the time of deposition)
- undisturbed or slightly disturbed (eg vessel rim of an urned burial broken off; sediment infiltration will have some effect on fragment size)
- vessel of urned burial intact but cracked (possibly further affects fragment size)
- all of burial *in situ* but vessel fragmentary (further affects fragment size)
- disturbed (potentially some bone loss, further affecting fragment size)
- badly disturbed (ie bone loss and increased pressure fragmentation probable)

### 4.3.3 Bone fragmentation

The weight of bone recovered from three – 10mm 5mm and 2mm – sieve fractions should be recorded and represented as a percentage of the total weight. A measure (mm) of the maximum bone fragment should also be taken and, where possible, a pre-excavation maximum fragment size should also be provided by the excavator or the osteologist where they have undertaken the excavation of an intact urned burial. NB: the 2mm sieve fraction often includes extraneous material, and this weight should only include extracted bone fragments, with a visual assessment of the amount of bone included in the unsorted residue.

### 4.3.4 Total weight of cremated materials

The total weight of all cremated bone – including pyre goods comprising animal remains or artefactual material – should be taken. The weight of the latter two may then be presented separately and the percentage they comprise of the total weight can be calculated. Weight in grams should be measured to one decimal place.

### 4.3.5 Demographic data

The archive report requires a record of all identified bone fragments, including a clear statement indicating duplication of elements indicative of one or more individuals, together with morphological observations pertaining to assessment of age and sex made in accordance with Sections 6–8 .

It is advised, where possible, with large scale assemblages to collect a series of measurements potentially relevant to sexual dimorphism in accordance with the methods of Gejvall (1969; 1981), Van Vark (1974; 1975) and Wahl (1982). Whilst there are often limitations to the applicability of these methods, particularly in small assemblages (<10), and other potential areas of discrepancy related to variable shrinkage (reviewed in McKinley 2000c; McKinley and Bond 2001), the maximisation of data recovery is encouraged.

### 4.3.6 Pathological data

The form and nature of cremated bone (incomplete, fragmentary skeletal material) render the recording of data in the format required for the calculation of the prevalence of pathological conditions (Section 11) difficult in the vast majority of cases. However, the position and form of lesions should be described (see Section 11) and a diagnosis may be made within the obvious limitations of the material.

### 4.3.7 Colour (a reflection of oxidation)

The degree of oxidation of the organic component of bone is related to the temperature acting on the bone (NB the individual bone, not the pyre) in an oxidising atmosphere. This reflects the 'efficiency' of cremation in terms of such factors as the quantity of fuel used to build the pyre, temperature attained in various parts of the pyre, length of time over which the cremation was undertaken and the oxidising / reducing conditions in various parts of the pyre.

The degree of oxidation of the organic component is reflected macroscopically in the colour of the bone (Holden *et al* 1995a; 1995b) ranging from brown / orange (unburnt), to black (charred; *c*. 300°C), through hues of blue and grey (incompletely oxidised, up to *c*. 600°C) to the fully oxidised white (>*c*. 600°C). Most cremated bone is white in colour, but any variation should be fully described, noting the skeletal element affected and, where possible, the side, which part or parts of the bone are affected (eg exo / endocranial, diploë, cortical, medullary, central section), the colour or combination of colours (they commonly vary across and through the bone), and a summary of the percentage of the remains affected within an individual deposit, skeletal areas / sides etc.

### 4.3.8 Dehydration

Dehydration during cremation leads to shrinkage, fissuring and warping of bone along characteristic patterns (eg 'U' shaped fissures along long bone shafts, splitting apart of component parts of an element such as that of a vertebral body from its dorsal portion; Baby 1954; Binford 1963; Thurman and Wilmore 1981; McKinley 2000c; McKinley and Bond 2001). Any abnormal warping should be recorded (skeletal element, side, description of warping).

### 4.3.9 Skeletal elements

Generally it is not possible to identify every bone fragment to skeletal element, and many small fragments of trabecular bone and long bone shaft may be difficult to distinguish. Only where a fragment can be placed to element (eg 'radius shaft' rather than 'upper limb', 'cervical vertebrae' rather than just 'vertebrae') should it be considered 'identifiable'. The distinctive appearance of parts of the skull, even as small fragments, invariably leads to a bias in the amount of skull identified (McKinley 1994b; McKinley and Bond 2001).

A record should be made of the skeletal element, side (where possible), what part of the bone (eg vertebral body, spinal / transverse / articular process) and whether it is a whole (eg radius head) or part (eg fragment of radius head). The weight of bone from each skeletal area – skull, axial skeleton, upper limb, lower limb – should be presented, together with the percentage of the total weight of identifiable bone represented.

### 4.3.10 Pyre goods

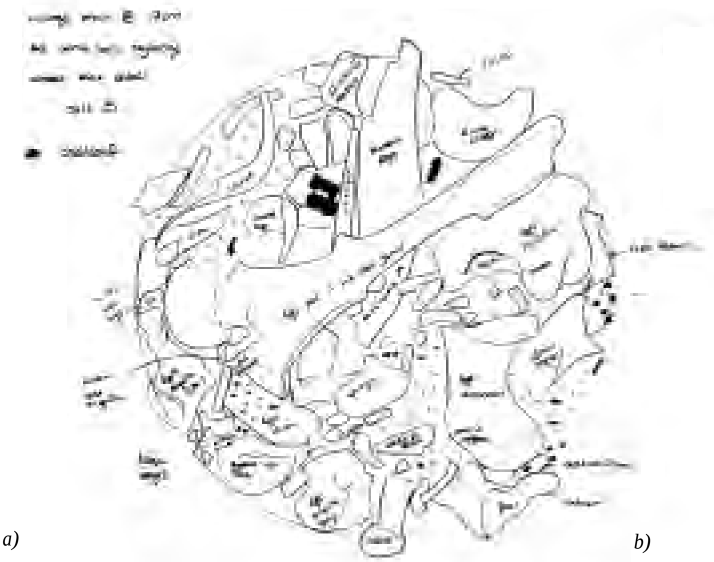
Although some pyre goods (items accompanying the deceased on the pyre rather than just in the grave) are likely to have been removed in post-excavation processing, some items – particularly cremated animal bone – are likely to remain within the assemblage at the time of osteological analysis.

All non-human material should be extracted, the type (eg animal bone, worked bone / antler / ivory, glass), condition (eg levels of oxidation etc in bone, melting in glass or copper-alloy) and quantity (weight in grams to one decimal place) should be recorded. Some materials (eg glass and copper alloy) may fuse to bone fragments during cremation, and the bone fragment and where possible side should be noted. NB Iron may fuse to bone during burial as it corrodes. The original proximity of some materials to bone may be indicated by coloured staining (eg blue / green staining from copper alloy). Any abnormal coloured staining should be described in terms of colour, extent and location.

### 4.3.11 Pyre debris

Fragments of pyre debris – eg fuel ash, fuel ash slag, burnt flint or burnt clay – may be present within the deposit (this may in part reflect the deposit type – see above).

a)



b)

*Figure 4  Romano-British urned cremation burial under laboratory excavation: a) photographic record, spit 3; b) annotated scale drawing, spit 3.*

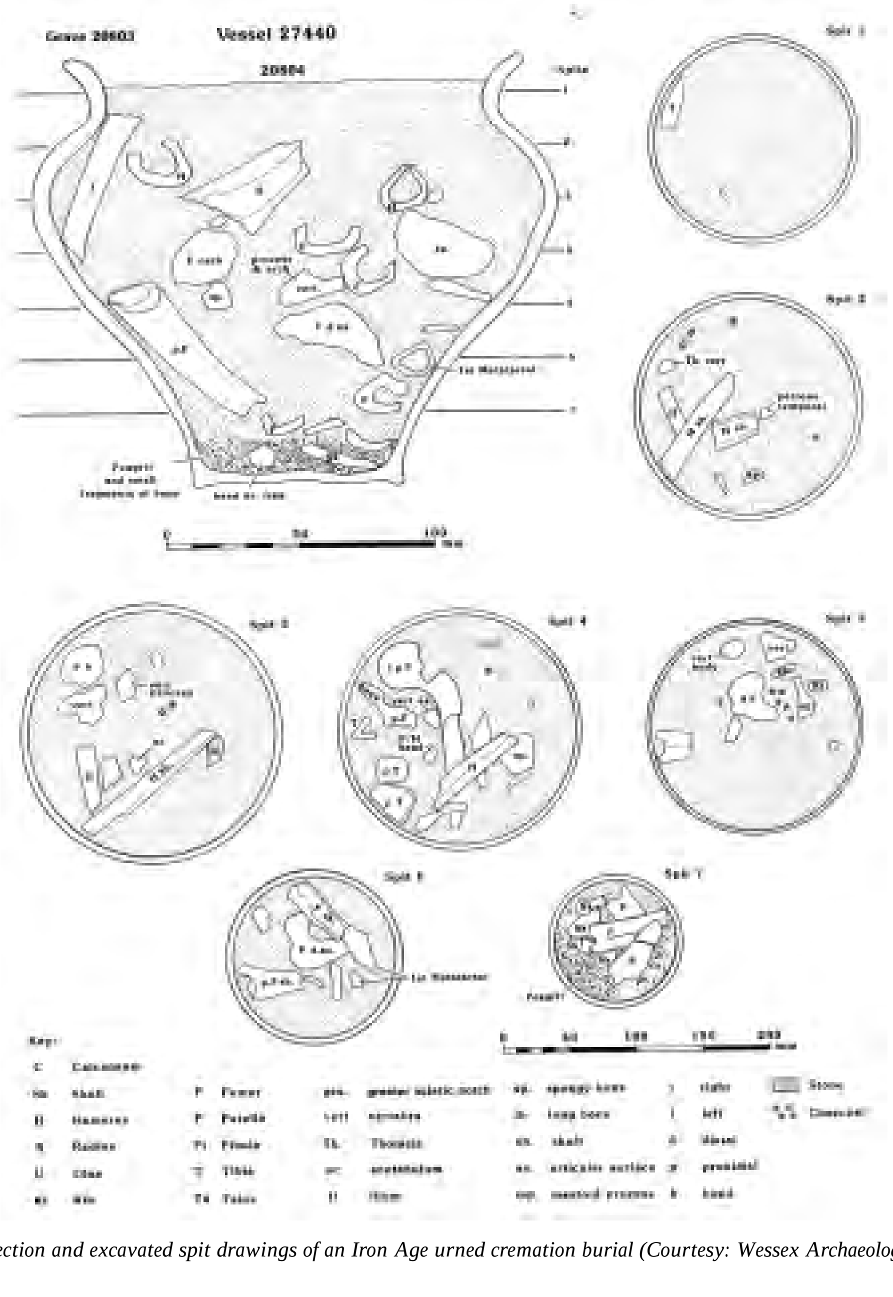



*Figure 5  Annotated section and excavated spit drawings of an Iron Age urned cremation burial (Courtesy: Wessex Archaeology).*

The type of material, quantity and fraction size should be recorded, and any such material removed from the 5mm sieve fraction and above for examination by the appropriate specialist. Bone may be charcoal stained, and the bones affected and extent of any such staining should be recorded. The osteologist should be able to identify pottery, worked stone, worked bone etc which is the level of recording required at this stage (the equivalent of filling out the 'archaeological components' box on a site context sheet, ie as a check).

#### 4.3.12 Formation processes

Where the osteologist is to undertake detailed excavation of an undisturbed, urned burial, a record of similar nature to those made on site should be made (scale plan and section drawings, and photographs). The vessel should be emptied in a series of equal-sized spits (not less than 20mm) and quadrants to allow the horizontal and vertical distribution of individual bone fragments to be monitored (Figures 4-5). All further analysis should maintain these subdivisions.

## 4.4 Reports

The presentation and interpretation of data is discussed in Mays *et al* (2002), but the importance of consideration being given to levels of disturbance and the type of deposit must be emphasised in any analysis and interpretation pertaining to aspects of pyre technology and ritual.

# 5 Compiling a skeletal inventory: disarticulated and co-mingled remains

*Jacqueline I McKinley*

## 5.1 Introduction

Disarticulated bone assemblages may represent the remains of a variety of different formation process from accidental disturbance of formal burials to culturally manipulated material reflective of ritual activity. The latter assemblages often comprise small, 'modified' fragments rather than complete bones. The former may include small amounts of bone from disturbed burials of any period, or the potentially vast quantities of material recovered from medieval or post-medieval 'cemetery soils' and charnel deposits.

## 5.2 Areas of data recovery

The various types of data required to fulfil (as far as possible) the aims of analysis may be expressed as a series of questions, some of which may vary dependent on the date and type of assemblage.

*All assemblages:*

- minimum numbers of individuals, age and sex
- presence of pathological lesions

*'Ritual assemblages':*

- Ancient modification by:

  'natural forces' – abrasion / erosion, (including by root / fungal activity), trampling and gnawing, most of which may be reflective of human modification in the form of exposure or repeated deposition episodes

  'human modification' – cut marks, deliberate breakage, burning and selection of skeletal elements, the form of which may reflect various activities of differing nature

## 5.3 Recording

With assemblages of this type the site context data is of particular importance to the osteologist. The provenance of the individual bones or bone groups needs to be incorporated within the recording system; the remains will have been recorded on site by context, or as individually numbered bones or groups of bones which will generally have been attributed an 'object number'. Access to distribution plans is also imperative to aid in the assessment of links between bone fragments and interpretation of what the presence or absence of any such links may be (unless of course it is clear that the bone is a disturbed formal burial). Site context data should always be made available to the osteologist before they commence recording; if not, ask for it.

Recent work on the large medieval to post-medieval cemetery at Spitalfields in London has highlighted the inherent problems (Connell *pers comm*) of estimating minimum numbers and other demographic data from large quantities of human bone recovered from 'cemetery soils' (ie the redeposited, disarticulated bone from disturbed burials which builds up and around the extant graves). It has been concluded that there is limited value in the analysis of such assemblages and that observations should be restricted to basic quantification (no. count / weight, generally covered in basic post-excavation processing), and recording the presence of unusual or illuminating pathological lesions and skeletal features. There are some exceptional circumstances, ie where the cemetery is small and was used over a relatively short time-scale resulting in only limited disturbance, and where the original context of bone redeposited in the 'cemetery soil' may easily be deduced. This can best be achieved where the material has been subject to 3-D site recording or when recorded as a discrete context.

With all other assemblages, each bone or bone fragment recovered singly or in an associated group needs to be recorded (see below; *skeletal elements*). Where a group of bones or bone fragments are recovered, they should be divided into the component skeletal elements (eg radius, femur, skull) or group of elements (eg ribs, thoracic vertebrae, distal finger phalanges) for ease of handling and examination. The required data includes a record of the bone or bone fragment(s), number of fragments with a note of the type of fracture (ancient or modern; to dry or green bone; see below), a record of joins between fragments, side (where possible), the part of the bone represented as precisely as possible and condition including any ancient modification (see below).

The minimum number of individuals represented by bones recorded as a group should be shown. The assessed age and sex of the individuals being attributed to specific bones within the group should be recorded where possible (this may not always be achievable where bones are not duplicated and suggest a similar age). Any pathological lesions should be noted in accordance with Section 11.

### 5.3.1 Demographic data

Minimum number counts within an assemblage use the most commonly occurring skeletal element eg right temporal, left femur, in association with clear distinctions in age (eg immature and adult). Particular care is required with some prehistoric assemblages where the remaining bone fragments may be very small (see below) and have been subject to wide spatial movement as a result of natural or human intervention. Consequently if, for example, the right femur appears to be the most commonly occurring fragment care is needed to ensure there is genuine duplication of the specific area of the skeletal element and the recording system used must enable such distinction to be made (see below).

### 5.3.2 Ancient modification

The condition of the bone, particularly from prehistoric assemblages, is often key to understanding the formation processes affecting the assemblage and, thereby, interpretation of the rituals attendant on the associated mortuary rites. The material may also reflect multi-behavioural manipulation of a complex and changing nature associated with wider social and cultural activities. Comprehension of these factors requires comparisons not only between different parts of the human bone assemblage and similar assemblages from other sites, but intra-site comparison with the animal bone assemblage to ascertain similarities and differences in treatment.

Detailed identification of the area of skeletal element represented by the recovered bone fragment is most clearly expressed by visual representation. If a coding system is to be used it should be sufficiently detailed to be able to deal with small segments of bone which may only include, for example, a 20mm tube of femur from any part of the shaft, the postglenoid tubercle from the temporal bone, or part of a metatarsal shaft. There are various advantages to such systems including facilitating rapid assessment of the elemental composition of the assemblage (particularly useful for large assemblages) and allowing detailed comparisons with the related animal bone assemblage since such coding systems have long been used in the analysis of animal bone (eg Dobney and Rielly 1988). A coding system on a similar scheme to that used for animal bone has recently been devised for human remains which provides a useful way forward in the combined study of prehistoric disarticulated human and animal bone assemblages (Knüsel and Outram forthcoming). The system inevitably retains some limitations in levels of detail which can be recorded and caution will still need to be applied in using such techniques for minimum number counts for the reasons outlined above.

Each bone or fragment should have a coded record of *abrasion/erosion* (the latter including erosion by root / fungal action). The system set out by Behrensmeyer (1978, table 5 in Buikstra and Ubelaker 1994) covers the cracking and flaking seen in weathered bone, but is not applicable to the type of erosion (generally due to burial in overly acidic / alkaline soil conditions, including root / fungal action) and abrasion (due to exposure, repeated deposition and 'kicking-around' on the surface) seen in material from many British sites. An alternative system for recording bone surface preservation for human bone is presented in here (Figure 6); abrasion and erosion should be recorded using a scale of 0–5 (ie absence of any changes to complete obscuring of the cortical surface with a note of extent and position). Different parts of the bone may be variously affected eg distal / proximal or anterior / posterior surfaces, inner / outer surface, ends; consequently, it may be necessary to specify different grades for different parts of the bone. *Bleaching* or other *discolouration* to bone should be similarly noted (including that resulting from burning) recording position, extent and colour. Extent and position of longitudinal or horizontal *fissuring* should also be recorded (see above). Sketches or annotated skeleton diagrams may be useful in some instances, providing an easily accessible visual record.

Evidence of *animal gnawing* – carnivore (Figure 7) or rodent – should include position, nature of marks (ie carnivore puncture marks, grooving around broken ends of bone, and incised carnivore or rodent grooves), number of punctures / grooves and / or extent of area covered. A photographic record is also recommended, with drawings to augment the written description. It should be noted that the skeletal element and part of the element remaining may also be indicative of carnivore gnawing even where no visual evidence of tooth marks are extant (Binford 1981).

Evidence of *cut marks* should include position, number of cuts, average and range of length of cuts and the type of cut represented (eg chop, cut, light defleshing mark; Binford 1981). Drawings and / or photographs are recommended to assist in demonstrating the appearance and position of cuts (Figure 8a–c). Scanning Electron Microscope photographs may be useful in distinguishing skinning marks from those caused by animal *trampling* (Andrews and Cook 1985). Comparison of the type and extent of cuts seen in the human and animal bone assemblages is vital to understanding the nature of the activity reflected by them (Binford 1981; Russell 1987a and b; Turner 1993; Outram 2001). In some assemblages cut marks may be related to autopsy or surgery.

Particular attention should be given to the broken ends of bones and the fractures sustained. The type of fracture should be noted – fresh or old, sharp sided / clean edged spiral fractures indicative of green bone fracture, or rounded – and the percentage of the different fracture types (Outram 2001). In the case of acute longitudinal fractures, the bone should be examined for impact fractures at either end (Binford 1981, figures 4.48 and 4.53); drawings and / or photographs should be made / taken of any such fractures.

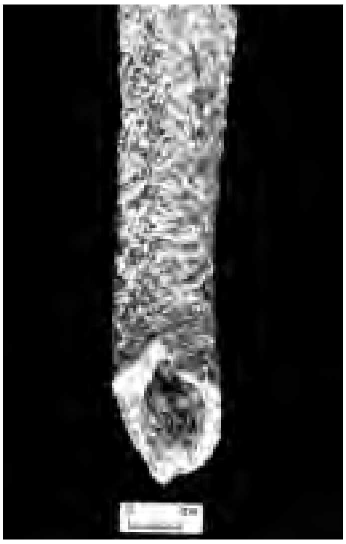
*Grade 0: Surface morphology clearly visible with fresh appearance to bone and no modifications*

*Grade 1: Slight and patchy surface erosion (in this case by root action)*

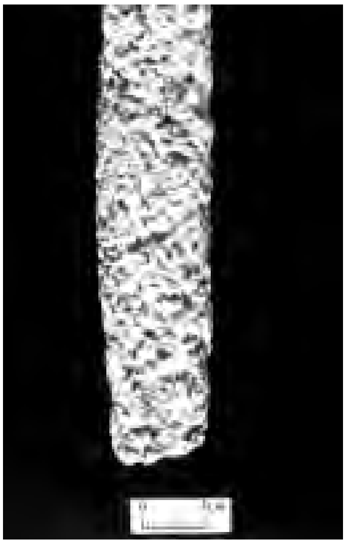
*Grade 2: More extensive surface erosion (by root action) than grade 1 with deeper surface penetration*

*Grade 3: Most of bone surface affected by some degree of erosion (by root action); general morphology maintained but detail of parts of surface masked by erosive action.*

*Grade 4: All of bone surface affected by erosive action (in this cases predominantly root activity); general profile maintained and depth of modification not uniform across whole surface.*



*Grade 5: Heavy erosion (in this case by root action) across whole surface, completely masking normal surface morphology, with some modification of profile.*



*Grade 5+: As grade 5 but with extensive penetrating erosion resulting in modification of profile*

*Figure 6 Grades for recording erosion/abrasion to human bone (Photographs by Elaine Wakefield, Wessex Archaeology)*

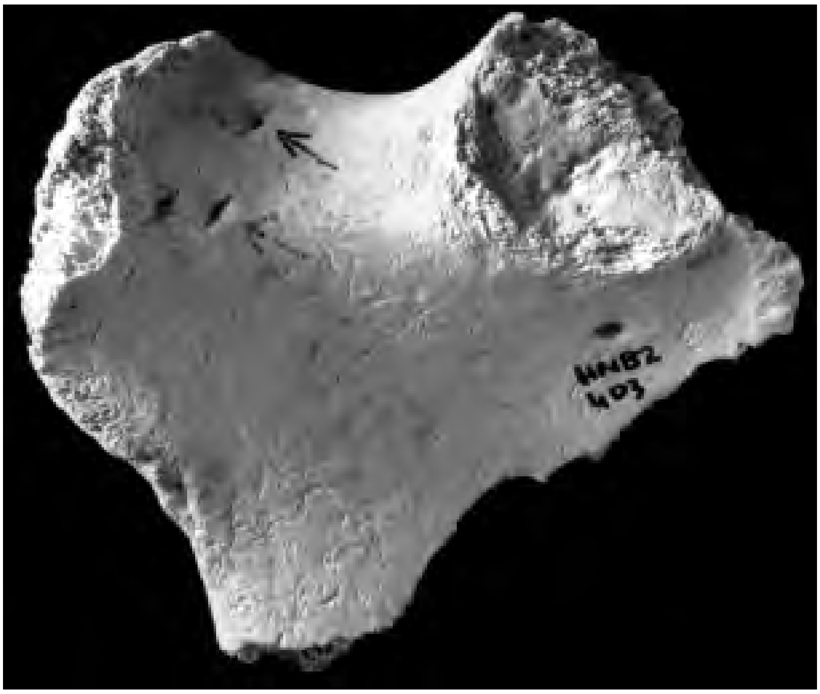
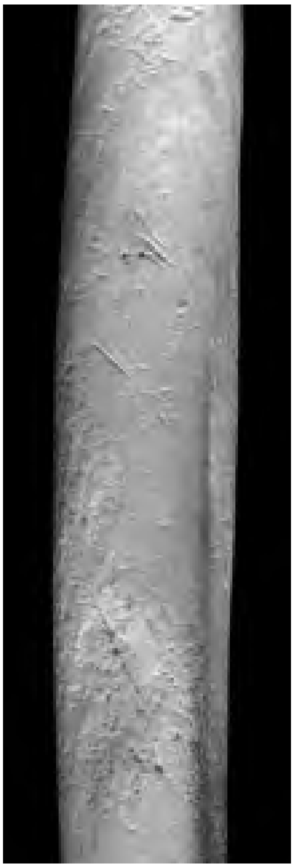



*Figure 7 Canid gnawing to immature Neolithic innominate, anterior view. (Courtesy R Mercer, Hambledon Hill Project)*

*a)*



*b)*

*c)*

*Figure 8 Fine cut marks ('filleting' marks) see in fragments of a) a femur shaft, b) a radius shaft from a Neolithic assemblage and c) fragments of ventral and dorsal rib shaft (Photographs by Elaine Wakefield, Wessex Archaeology).*

In addition to noting the number of fragments and fracture types, archaeozoologists also record the number of fragments within specific size ranges to assist in assessing the form of the assemblage. If full comparisons between disarticulated human and animal bone assemblages is to be achieved, similar recording is recommended for the human bone (Outram 2001), undertaken in consultation with the archaeozoologist studying the animal bone assemblage from the same site.

# 6 Guidance on recording age at death in adults

*Linda O'Connell*

## 6.1 Introduction

One of the fundamental biological parameters assessed as part of any skeletal analysis is that of age at death. The methods employed in this process essentially evaluate physiological changes that are evident in certain areas of the skeleton and attempt to define these as chronological values. Although the latter clearly represents a constant progression, the former is certainly not. This basic disparity is further complicated by the fact that extant adult ageing methods rely almost solely on observations of degenerative change – a process that is, in itself, occurring at differing rates in and within different populations and assemblages. Other variables, such as random individual variation in degeneration and the systematic effects of environmental, nutrition and genetic factors on growth and senescence, will also increase the complexity of this assessment. None of the techniques available are perfect and those undertaking recording have to work within the limitations of the techniques available.

## 6.2 Differentiation between young and mature adult

Despite the preceding concerns, it is generally accepted that differentiation between 'young' and 'mature' adults is relatively straightforward to achieve. Epiphyseal union is still occurring in a number of areas in both the cranial and postcranial skeleton from the late teens through to the early thirties, providing a relatively dependable indicator of age within this comparatively short age range.

Areas that are currently examined postcranially include the medial aspect of the clavicle (Webb and Suchey 1985; Black and Scheuer 1996); fusion of the sacrum (McKern and Stewart 1957, 154; Scheuer and Black 2000, 213); annular epiphyses of the vertebrae (Scheuer and Black 2000, 209-213); and secondary centres of ossification in the innominate, ie the iliac crest (McKern and Stewart 1957; Webb and Suchey 1985; Scheuer and Black 2000, 365) and ischial epiphysis (Scheuer and Black 2000, 365, 368). Cranial areas include fusion of the jugular growth plate (Maat and Mastwijk 1995; Hershkovitz *et al* 1997) and development of the third permanent molar (Haavikko 1970; Anderson *et al* 1976; Smith 1991).

Despite the widespread use of these approaches, it must not be forgotten that such maturational processes vary naturally between ethnic groups and sexes, and is also susceptible to the effects of genetic, hormonal, environmental, nutritional and social factors.

The system of recording employed should allow the exact stage of fusion (unfused, partially fused, fused but line still visible) to be recorded across the skeleton. A clear statement about the sources used to assign a chronological age to the stage of biological development must also be made. To allow for possible variations caused by factors such as differences in nutrition and environment, broad age categories of the type advocated by Buikstra and Ubelaker should be used, for instance Adolescent (12–20 years), Young Adult (20–35 years), Middle Adult (35–50 years) and Old Adults (50+ years) (1994, 9). Whatever the age categories adopted, a clear statement of the age range should always be given to allow comparison with data from the other assemblages where different categories have been employed.

### 6.2.1 Macroscopic methods

There are a number of macroscopic osteological methods that are commonly employed to address age at death estimation in mature adults. These include pubic symphysis degeneration (Brooks and Suchey 1990); auricular surface morphology (Lovejoy *et al* 1985); sternal ends of ribs (İşcan and Loth 1984; İşcan *et al* 1985); cranial suture closure (Meindl and Lovejoy 1985); and dental attrition (Miles 1963; 2001; Brothwell 1981). Some workers also consider pathological lesions commonly associated with ageing, such as osteoarthritis, though this can led to circularity in arguments about disease prevalence and ageing.

Aside from the fact that a number of these methods have proved difficult to apply practically (despite sometimes detailed descriptions), the most important point to bear in mind is that before implementing any one of them, it is imperative to have an understanding of how these methods were developed in the first place. The reader is referred to Cox (2000a, 63–64) for a detailed review of methodological considerations, although a brief synopsis is incorporated here.

## 6.3 Samples used to develop ageing methods

Essentially, much skeletal material employed for this purpose heralds from either archaeological or dissection room samples. In most cases the former consists of individuals of unknown age at death (and sex), although there are notable exceptions such as Christ Church, Spitalfields (Cox 1996; 1998; Molleson and Cox 1993) and St Brides, Fleet Street, London (Scheuer 1998; Scheuer and Bowman 1994; 1995). Although it might be expected that dissection room samples would consist of known individuals, there are some which exhibit socio-economic and genetic biases, and for which documentary information was not available. In these cases age at death (and sex) was determined from soft tissue attributes. With these potential problems in mind, much broader age categories should be used than has been the case in the past. However, work is ongoing to improve the accuracy of age determination at a population and individual level, and information on these developments can be found in Hoppa and Vaupel (2002).

### 6.3.1 Paleodemographic issues

Another important issue to consider is the concern of bias in ageing that was noted by Bouquet-Appel and Masset (1982; 1985; 1996). They convincingly argue that developing an ageing method on a sample will result in the replication of that sample's mortality profile in any other assemblage to which the method is applied. Closely allied to this is the fact that a number of ageing methods were primarily developed for use on assemblages not individuals, which has important ramifications with respect to systematic errors inherent in each method.

### 6.3.2 Testing methodologies

Although a number of methods have subsequently been tested on other skeletal samples, it must be remembered that these latter assemblages themselves are not always of known age and in many cases will have derived from the application of other (potentially flawed) ageing methods. As a result, this approach only serves to further propagate systematic errors and cannot provide a robust test of reliability.

In addition, the methodological bias referred to above (which essentially reflects preconceptions about life spans in the past), leads to instances where older individuals are consistently under-aged and younger individuals (less than 45 years) over-aged by as much as 30 or so years (Molleson and Cox 1993, 171).

Multifactorial approaches have been developed in an attempt to minimise errors inherent in individual methods (Bedford *et al* 1993; Saunders *et al* 1992). This should not, however, be seen as a universal panacea because it does not address the fundamental issues of innate inaccuracies in each of the individual approaches involved.

Radiological and histological techniques have also been applied to age determination. A review of recent advances in histomorphometry is provided by Robling and Stout (2000). There are also microscopic techniques involving the teeth, such as root translucency analysis (Rösing and Kvaal 1998).

## 6.4 Identification of young adults using epiphyseal fusion

### 6.4.1 Medial clavicle

Data relevant to assessment is referred to in Black and Scheuer (1996), McKern and Stewart (1957), and Webb and Suchey (1985). A summary of changes is presented by Scheuer and Black (2000), who note that there is no evidence of fusion before 18 years; a fusing flake will appear between 16–21 years and almost total coverage is achieved by 24–29 years. Complete fusion, although unlikely before 22 years, will be attained by 30 years (*ibid*).

### 6.4.2 Sacrum

Data relevant to fusion in the sacrum is recorded by McKern (Unpublished laboratory manual reproduced in Steele and Bramblett 1988), McKern and Stewart (1957, 154), Schwartz (1995) and Stewart (1954). Scheuer and Black (2000) have stated that if spaces are still detectable between all of the sacral segments then the individual is younger than 20 years. If a space is only retained between the first and second segments, this suggests that the individual is less than 27 years of age (*ibid*).

### 6.4.3 Jugular growth plate

Work by Maat and Mastwijk (1995) suggested that fusion occurs unilaterally between 22–34 years of age in both sexes and bilaterally in males and females above 36 years and 34 years respectively, with no fusion apparent prior to 22 years. It must be remembered, however, that this work was undertaken on a small sample and has not been re-evaluated on a larger, more detailed scale.

## 6.5 Identification of mature adults using degenerative change

All the following methods have published descriptions for each phase that should be used in conjunction with the relevant casts or photographs.

### 6.5.1 Pubic symphysis (Brooks and Suchey 1990)

Assessment of age is undertaken by comparison of specimen with twelve pubic bone casts (male and female) illustrating the six phases of the Suchey-Brooks pubic symphyseal age determination system.

### 6.5.2 Auricular surface (Lovejoy *et al* 1985)

Assessment of age is undertaken by comparison of specimen with 16 colour images illustrating the appearance of the auricular surface between 20–70 years of age.

### 6.5.3 Sternal ends of ribs (İşcan and Loth 1984; İşcan *et al* 1985)

Assessment is undertaken by comparison of specimen with the 42 male and female ageing casts of the sternal end of fourth rib.

### 6.6.4 Dentition

**6.6.4.1 Third molar root mineralisation**
This is usually achieved in the period of 18–25 years (Anderson *et al* 1976 [18–19 years]; Haavikko, 1970 [19–21 years]; Schour and Massler, 1940 [18–25 years]; Smith 1991 [19–20 years]). Gingival emergence is noted to transpire during the late teens to early twenties, *c*. 17–25 years (Brown 1985; Hillson 1996). It should be noted that this maturational process varies between the sexes (Anderson *et al* 1976; Garn *et al* 1958; Haavikko 1970; Hillson 1996; Smith 1991) and ethnic groups (Davis and Hägg 1994; Harris and McKee 1990; Loevy 1983), and will also be susceptible to the effects of genetic, hormonal, environmental, nutritional and social factors (El-Nofely and İşcan 1989).

**6.6.4.2 Attrition**
Probably the most widely used scoring scheme for archaeological samples is that developed by Brothwell (1981). Miles' (1962; 1963; 2001) system for age assessment based on the idea that rates of wear can be calibrated against dental eruption is also used. A point of note with respect to this method is that attrition stages do not represent a series through which all dentitions pass in ordered and steady sequence (Molleson and Cohen 1990). Although attrition might be as good as any method that is readily available for assessing age at death of young adults, the long duration of the later stages inevitably leads to imprecision in ageing older individuals. This can obviously limit the precision of age estimation but the method can provide effective criteria for determining age at death as long as the rate of attrition of a particular population is known.

### 6.6.5 Cranial suture closure

Cranial suture closure has not been included here as it is considered to at best of limited value when applied to archaeological assemblages and then only as part of a multifactoral approach. Generally speaking, it would be unwise to apply it in any other respect than as a very general indicator of either young or old adult status, and even then it should be remembered that some disease processes can cause premature suture closure and obliteration.

## 6.7 Concluding remarks

The biological basis of physiological age change (and the various intrinsic and extrinsic factors affecting it) in the skeleton is still not fully understood. A whole host of variables such as ancestry, sex, genetic constitution, nutritional and health status, occupational and lifestyle activities, and socio-economic status affect the biological expression of various skeletal age determinants, and these need to be borne in mind when considering the various methods available.

It is vitally important that the methods employed to estimate age at death are clearly stated in the methodology section of skeletal reports. Precise notes should be kept for each individual on the recording forms used (eg on scores awarded, stage etc for every feature observed). This will assist later researchers who may wish to reassess a particular approach. Descriptions of observations (where appropriate) will also provide a record that can be revisited in future and which may allow re-evaluation of earlier methods in the light of future developments.

When age is assessed the person undertaking the recording should consider the following points:

- How many individuals are present? With larger assemblages it is more likely that the relationship between age and dental wear can be calculated
- What is the date of the assemblage? (dental wear is not reliable in post-medieval groups)
- What is the level of skeletal survival and preservation (some skeletal areas might be excluded from analysis due to poor preservation)
- Try to select a number of techniques, especially if one of those you wish to apply is not well known or experimental. For example you may wish to record pubic symphysis, auricular surface, sternal rib ends and dental wear
- Record and report what you have done as accurately as possible
- Use broad age categories, such as those suggested in Buikstra and Ubelaker (1994, 9): adolescent 12–20 years, young adult 20–35 years, middle adult 35–50 years, old adult 50+ (always include a note of the age range attributed to the various categories)

Suggested tabulation for presentation of results;

| Skeletal region | Observations | Phase/stage | Inference |
|---|---|---|---|
| Medial clavicle | | | |
| Sacrum | | | |
| Jugular growth plate | | | |
| Pubic symphysis | | | |
| Auricular surface | | | |
| Sternal ends of ribs | | | |
| Mineralisation of 3rd molar | | | |
| Dental attrition | | | |

Final estimated age at death: ..........................................................................................

# 7 Guidance on recording age at death in juvenile skeletons

*Megan Brickley*

## 7.1 Introduction

Although, in many respects, more accurate results can be obtained in the assessment of age in juveniles (the term juvenile is used here as in Buikstra and Ubelaker (1994) to indicate an individual between birth and adulthood, around 20 years), there are still a number of considerations to be taken into account when carrying out such work. Many of the points made in the previous section regarding small and poorly documented skeletal samples being used as a basis to devise methods for age estimation apply equally to juveniles. One factor that will keep the estimated age range of juvenile skeletons relatively broad in many assemblages is the lack of information on the sex of individuals, as the growth and development patterns of males and females differ (Stini 1985).

## 7.2 Dental development

Dental development is widely regarded as the most accurate means of determining age at death in individuals who have not yet reached dental maturity. Genetic factors appear to play a stronger role than environmental conditions and in analysis of past populations with different lifestyles and living conditions, these are important considerations. There are a number of ways in which teeth can be investigated to determine age at death.

The simplest method is to examine the stage of dental development and eruption, either visually or with the aid of radiographic images, to allow root development and un-erupted teeth to be observed. Information on the stages and sequence of development of the dentition are reviewed by Hillson (1996, chapter 5), and systems that allow accurate recording of the precise stage of development of each tooth have been devised (Moorees *et al* 1963 a and b; Smith 1991). It should be remembered that eruption of a tooth is not as reliable as the formation stage of teeth and their roots, and radiological examination may be required to make this possible.

Systems of linking biological dental development to a chronological age are also available (eg Gustafson and Koch 1974; Ubelaker 1989). These systems were developed from studies of non-British individuals, and both genetic and environmental factors will be different to those of individuals from British archaeological contexts. However, providing the margins of error are applied they can provide a useful guide to biological age. As important as the age assigned to an individual is accurate recording of the stage of dental development attained, as this will allow future modifications of age at death estimates.

## 7.3 Microscopic examination of teeth

Examination of the incremental growth structures of teeth will allow far greater accuracy in the determination of age at death than the visual and radiological examination outlined above. Consequently, although the techniques involved are more complex and expensive, requiring both specialist equipment and expertise, consideration should be given to the possibility of applying such techniques at the assessment stage of a project (while budgets are being decided). Such techniques are never likely to be routinely applied during recording due to the costs involved – in addition to which such specialist work is currently not commercially available within the UK and those working within this field do so on a 'research' basis – but a case may be made where very accurate age estimates are required to answer specific questions. A review of the various techniques available for assessment of microstructural growth is provided by Fitzgerald and Rose (2000).

Microstructural investigations is likely be undertaken by a specialist rather than the osteologist undertaking the rest of the skeletal recording. The latter should liaise closely with the specialist to ensure that adequate records of the techniques and results are kept to form part of the skeletal archive. Main investigators should also ensure that they get sufficient information to allow them to understand the processes undertaken and interpret the results to enable them to fully integrate this work in the final report.

## 7.4 Development and maturation of the skeleton

The most comprehensive review of information on development and fusion of bones across the skeleton currently available is provided by Scheuer and Black (2000). There are two basic approaches to assigning age at death in juvenile material, the appearance and fusion of the various epiphyses, and measurement of long bone length.

During analysis of juvenile skeletons development, fusion and overall length of bones from across the skeleton should be recorded as, in addition to allowing an estimation of age to be made, a range of issues that could be placed under the heading of 'growth studies' can be addressed using these data. For a review of recent work on growth studies see Humphrey (2000) and Hoppa and Fitzgerald (1999).

It is recommended that in younger individuals (< 3 years old) the range of measurements detailed in Buikstra and Ubelaker (1994) is used, as these give a good selection of measurements from across the skeleton. In older immature individuals (>12 years old) the measurements suggested in Section 10 are recommended. However, it is important to remember that most data on the relationship of long bone length and age is derived from modern individuals, and often the number of individuals used to generate this data is very small. Another factor which should also be borne in mind is that juveniles from archaeological contexts have a high chance of having suffered from debilitating illness – possibly the reason for their death – which could have compromised an individual's development leading to shorter bone length than might be expected (Sherwood *et al* 2000).

If information on appearance and fusion of skeletal elements is used – such as that provided in Scheuer and Black (2000) – it must be remembered that this is commonly derived from very small samples and often studies used observations from radiographs rather than direct examination of dry bone. When analysing individuals from an archaeological context, absence of epiphyses should not be used to assist age determination as there is a high possibility of these small and less mineralised bones not surviving or being lost during the excavation process.

## 7.5 Concluding remarks

Exactly what is recorded will depend on the nature of the assemblage and the timescale / budget for the project. However, in each case:

- The bones / teeth present must be accurately recorded
- The exact stage of dental development must be recorded
- The stage of development and / or fusion of bones from across the skeleton should be recorded
- The measurements recommended should be recorded as a minimum
- It should be clearly stated how age determinations were reached (eg dental development, long bone length)
- Full notes and clear recording sheets should be kept as part of the site archive.

# 8 Determination of sex from archaeological skeletal material and assessment of parturition

*Megan Brickley*

## 8.1 Juveniles

Much work has been undertaken on the determination of sex in juvenile remains since the text of Buikstra and Ubelaker was compiled and published in 1994. Various techniques are discussed by Schutkowski (1993), Molleson *et al* (1998) and Scheuer (2002), with a recent review in Saunders (2000, 138-141). The statement made in Buikstra and Ubelaker (1994, 16) regarding determination of sex in juvenile individuals does, however, still stand; 'as yet there are no standards for diagnosing sex in juvenile materials considered acceptable by most osteologists'.

During the assessment stage of a project it may be decided that knowing the sex of the juveniles within the assemblage will help answer specific archaeological problems identified by the osteologist or archaeologist. If sex determination of pre-pubescent juveniles is investigated the methodology used will need to be outlined in detail in the bone report.

### 8.1.2 Biomolecular analysis

Analysis of ancient DNA may be used as a means of determining the sex of an individual. Although additional costs will be involved it may be decided at the assessment stage that the information gained will be of value to the research design of the project. Information on procedures for sampling DNA can be found in Section 13. Reviews of recent work and the potential of the technique to determine sex – amongst other things – can be found in Stone (2000) and Brown (2000).

## 8.2 Adults

Determination of the sex of individuals recovered from a site is extremely important for a wide range of investigations and a review of current issues relating to this type of investigation can be found in Mays and Cox (2000). An attempt should always be made to give some information on the sex of individuals. There are exceptions to any rule and if sex is not being investigated the reasons why this is so should be outlined clearly in the skeletal report.

The skeletal features or metrical criteria selected for the determination of the sex of individuals will vary widely depending on the nature and quantity of skeletal material available. During the assessment stage the osteologist should make decisions on the approach to be adopted to maximise the information obtained.

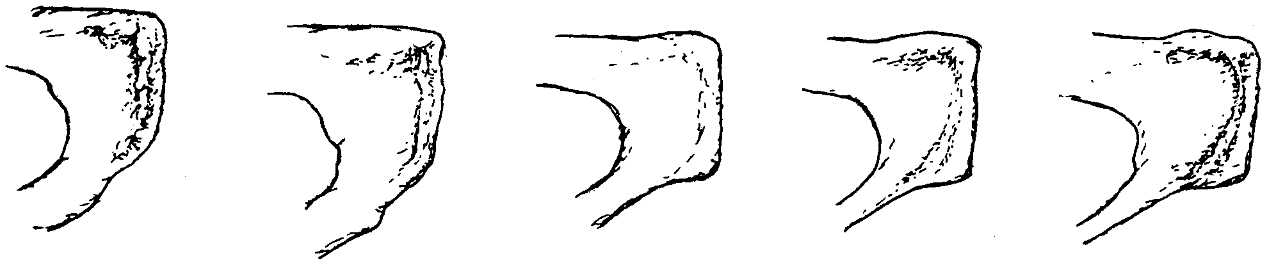
As stated in Buikstra and Ubelaker (1994, 15), morphological changes of the skull and the pelvis (if available) are of primary importance in the determination of sex. Provision of an accurate description of such features when recording will maximise the information on an assemblage. Exact morphological variation relating to sex will vary temporally and spatially, and care should be taken that any criteria applied are appropriate for the individuals under study. The scores awarded should, therefore, be viewed as stages and it should be accepted that the exact morphological expression of 'maleness' and 'femaleness' will vary. The primary purpose of the descriptions is to allow objective comparisons between individuals, to increase confidence in assigning a sex to individuals and to allow other researchers to fully appreciate what is being described.

The age of the individual being recorded should also be considered; some research has suggested that post-menopausal females may develop more masculine cranial morphology, and conversely young men may have more gracile and feminine features (Walker 1995). There are also age-related changes to the morphology of the pelvis and it should be considered that an android pelvis may represent either a male or pre-pubescent female. More research is needed on the possibility of age-related changes to skeletal morphology, especially in the skull, and until firmer data are available those undertaking recording should bear these possible variables in mind. To assist in accurate morphological descriptions additional drawings to those of the pubis, illustrating a range of morphological variation, have been provided (Figure 9a).

In recording the mandible in British skeletal material it has been noted that the drawings of the mandible provided by Buikstra and Ubelaker (1994) are of little value; there is a greater range of sex-related changes present than is indicated by this illustration. The mental eminence does not seem to be a key diagnostic feature in many British assemblages. Rather, it is recommended that a wider range of features are taken into consideration:

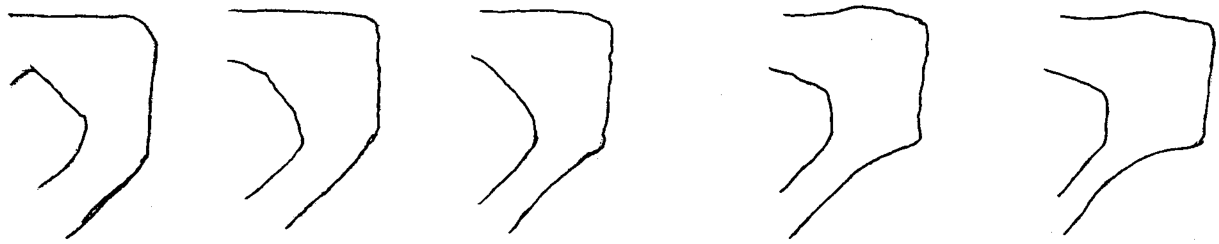
- overall size
- width of ascending ramus
- flaring of gonial angle
- shape of chin (viewed from below it is pointed in females and broad in males)

Figure 9b provides an example of the profile of a 'classic' male and 'classic' female mandible in profile and illustrates some of the range of sex-related differences seen in this bone.



Typical male 5 — Typical female 1

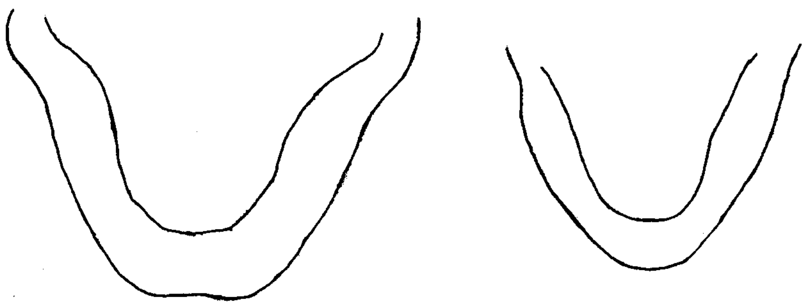
Some of the variation observable in the pubic region, from typical male morphology (5) to typical female morphology (1).
Variations include: An increase in 'length' of the pubic bone relative to overall robusticity.
On the ventral surface a shift from a ventral arc to a ridge running parallel to the pubic symphysis.
A 'thinning' of the inferior pubic ramus from typical male to typical female specimens.



Typical male 5 — Typical female 1

Changes in the inferior ramus from typical male to typical female, with resulting changes in the profile of the sub-pubic area.

*Figure 9a  Sexual dimorphism in male and female innominates (pubic region).*



Male — Female

Profile of a 'classic' male and 'classic' female mandible, showing the variation in size, robusticity and shape possible between the sexes.

*Figure 9b  Sexual dimorphism in male and female mandibles.*

## 8.3 Metrical assessment of sex

Metrical data can be very useful in sex determination and in some assemblages will be the primary means of assigning sex to many individuals, for example in poorly preserved remains where the pelvis is incomplete or missing. Care should be exercised in sex estimation, however, and the ancestry of the reference sample should be the same as that of the population under study (Mays and Cox 2000, 119). Ideally, reference data should be derived from individuals with well preserved skulls and pelves, from the assemblage under study. Information on applying discriminant analysis to assist in the determination of the sex of an individual is provided by Giles (1970), and Ditch and Rose (1972).

## 8.4 Summary

- Data derived from sites other than that under analysis must not be used without adequate checks
- Where assessment of sex is being determined through metrical data there must be sufficient data for results to be statistically significant
- The procedures used must be clearly referenced or adequately described
- It is not advised to use aDNA analysis as the main

way of sexing skeletons at present. Where the aDNA analysis is used morphological features of the skeleton known to be sexually dimorphic should still be accurately recorded along with a range of standard metrical data
- During recording, information should be gathered that will allow individuals for whom it was not possible to determine a sex and individuals scored as intermediate to be clearly identified in the report and archived material. These two groups should not be merged.

## 8.5 Assessment of parturition

The current state of research into investigations of parturition is well covered by Cox (2000b). The questions posed by this area of research are clearly important to many areas of physical anthropology, but assumptions made in some previous studies may have been rather simplistic. To summarise the information provided by Cox (*ibid*) the following points should be considered when recording human skeletal remains:

- The pre-auricular sulcus and pitting on the posterosuperior aspect of the pubic bone should not be used to provide information on parity
- Extension of the pubic tubercle may provide information on parity. Research is ongoing and this should be considered when drawing conclusions about parity based on this feature; statements at an individual level are probably best avoided at present
- In skeletal collections that contain known individuals, recording of features such as the pubic tubercle should be undertaken as a matter of course to provide a larger data set for this valuable area of research. Where more funds are available analysis of bone microstructure should also be considered

It is possible that there is a relationship between pregnancy, lactation and microstructural features of bone, and fuller discussion of this complex, but potentially fruitful area of research are provided by Cox (2000, 137–8). What is clear is that further research is needed in this area.

# 9 A note on the determination of ancestry

*Linda O'Connell*

The somewhat outdated term 'race' has always presented different connotations to different people and as a result has been especially vulnerable to misinterpretation. Within the scope of skeletal analysis, however, it relates to biological affinity as opposed to any social, political or religious concept of the term. At this point, it is important to remember that there are no distinct skeletal characteristics that correspond perfectly to specific geographical origins (White and Folkens, 1991). Post-medieval interbreeding of populations previously separated geographically has further compounded this problematic area of investigation.

It could be argued that the determination of ancestry is unhelpful within the antiquity of British archaeology, but this argument cannot be substantiated after the medieval period, if not earlier. Nevertheless, aside from the historical perspective, omission of this important demographic parameter may affect subsequent skeletal analyses, such as the elucidation of sex and age at death. It is known that sex and age assessment complicate matters due to their immutable dependency on one another and ancestry itself. Age estimation is compounded by sex determination, which in turn is further complicated by ancestry. Because of this, it is absolutely vital that researchers studying skeletal material should have a comprehensive understanding of normal and associated biological variation in order to critically, if not correctly, address assigned biological characteristics.

The determination of ancestry is usually based upon the gross morphological examination of certain skeletal traits in the skull (Brues 1990; Gill 1986, 149; Krogman and İşcan 1986, 271; St Hoyme and İşcan 1989, 69–75; Steele and Bramblett 1988, 58-59; Ubelaker 1989, 119) and this approach has been documented as yielding an 80–88% accuracy in assessment (Giles and Elliot 1962). Other areas may also be examined morphologically, and these include the femur (Gilbert 1976; Stewart 1962; Ubelaker 1989; Walensky 1965) and sacrum (Oliver 1969). Analytical procedures utilising biomolecular and isotopic (Dupras and Schwarcz 2001; Price *et al* 2000; 2002; Sealy *et al* 1995) analyses to identify ancestry are also indicated, although these methods are time-consuming, expensive, destructive and require appropriate expertise.

# 10 Metric and non-metric studies of archaeological human bone

*Don Brothwell and Sonia Zakrzewski*

## 10.1 Introduction

There has been a significant decline in interest in metrical and non-metric recording in relation to earlier British populations. The detailed osteometric work published in Biometrika prior to 1940 is relatively uncommon today. The reason is not because this kind of work has no value, but because palaeopathological studies (and now forensic anthropology) are considered 'sexier'. However, we have a long tradition in Britain, extending back into the mid nineteenth century, of undertaking metrical studies and in 1865 a large volume by Davis and Thurnam (*Crania Brittanica*) attempted to show morphological differences between some earlier British populations. This area of study has considerable potential value and a recent review of biodistance studies using British archaeological skeletal material is provided by Mays (2000).

## 10.2 Reasons for recording

There is biological sense in recording as much variation as possible if it may allow comparative studies between populations. In the case of small assemblages it must be remembered that the data is likely to be of considerable value in obtaining pooled regional samples. This is especially true of pre-Saxon periods. These data then, either as individual cemetery groups, or as pooled dated regional samples, is of value in the following ways:

1. Measurement may assist in ageing immature skeletons
2. Metrical dimensions can be used in sexing
3. Individual measurements or means may show secular trends
4. Non-metric frequencies may exhibit secular trends
5. Metric and non-metric data may support evidence of family clustering within cemeteries
6. Multifactorial use of both metric and non-metric data may indicate ethnic affinities, regional microevolution etc.

## 10.3 Taphonomic factors

Post-depositional factors may influence the extent of the data recorded. Surface damage and fragmentation may make some measurements questionable. Warping can occur, especially to the mandible, cranial vault (eg lateral compression) and fibula. Care is needed in reconstruction, but it is worth noting that prehistoric material is sufficiently uncommon to deserve all possible conservation measures to be taken.

## 10.4 What measurements?

Over the years measurements have been defined and taken. There is no hard and fast rule about which to take, but a number of factors should influence this choice. Firstly, common breakage of bone means that some measurements cannot normally be taken. Secondly, some measurements are highly correlated (eg maximum and oblique femoral lengths) and are thus best selectively used. We recommend, however, measuring the length of the tibia both including the spine (maximum length) and excluding the spine (complete length) as both these lengths have been used in stature predictions. Thirdly, where we have a body of data for a particular measurement and this measurement shows variation between those population groups already studied, there is clearly value in gathering more data and undertaking further comparisons. Fourthly, some measurements are more internationally known and may be of use for comparisons beyond Britain (eg 'Beaker people' or Vikings).

Taking the aforementioned factors into account, it is suggested that the measurements listed in Tables 1 and 2 are accepted as a minimum of measurements that should be taken where possible. The measurements are defined, with others, in Martin and Saller (1957), Howells (1973), Brothwell (1981), Bräuer (1988), and Buikstra and Ubelaker (1994). Table 1 gives a brief name of the craniometric measurement, together with the British traditional Biometrika symbol, the internationally recognised Howell code and the number assigned by Buikstra and Ubelaker (1994). Table 2 contains the primary listing of postcranial measurements, along with the Martin and Saller and / or Bräuer number. The full range of numbers and codes given to different measurements are included for completeness and to allow easy comparisons to be made in published material. The majority of British workers use the codes given in Brothwell 1981 (Biometrika symbol for craniometric and mandibular measurements), and it is recommended that these are used when recording material. It should be noted that, although this list of both cranial and postcranial measurements is brief, for specific research purposes this should be considerably expanded. Male, female and immature data must be kept strictly separate. When stature is calculated, reference should be made to which formula has been employed (hence the inclusion of both complete and maximum tibial length measurements).

The craniometric codes have been derived to employ both the Howells and Biometrika cranial codes as these are more memorable than the numbers used by Buikstra and Ubelaker (1994). The postcranial codes have also been derived to be relatively memorable – as compared with either Buikstra and Ubelaker numbers or those codes derived by Martin and Saller (1957) and expanded upon by Bräuer (1988) – with the last letter indicating the bone and the others indicating the form of measurement (eg X=maximum, L=length). All codes use only capital letters for ease of data entry into computer or other databases.

## 10.5 Which non-metric traits?

As with metrical work some traits are more commonly obscured by taphonomic factors or suture obliteration. Some are traditionally used more and some are more easily recorded. Some probably do have a genetic background, whilst others are likely to be influenced more by environmental factors. Precision of recording is also variable and in some instances there is still a need for improved methodology. Between-sample comparisons can use single traits or multifactorial comparisons. Non-metric traits probably have most use in suggesting family clusters within cemeteries or in demonstrating potential in-breeding or microevolution (Molto 2001).

Non-metric traits have been used in comparisons of populations for a century, but little use was made of them in Britain until the 1960s and then only to a limited degree. While they have been used for infra- and intra-population studies, one of the long-term problems is of the varying aetiology of the traits. As in the case of metric measurements, many have been defined, and these are reviewed by Berry and Berry (1967), Finnegan (1978), Hauser and De Stefano (1989), Saunders (1989), Buikstra and Ubelaker (1994), and Tyrrell (2000). In Tables 3 and 4 primary lists of traits are suggested, the traits listed here should be considered as a guide to best minimum practice, these traits are clearly defined and should have minimal inter-observer error. However, the list is far from exhaustive, and a wide range of other traits should also be considered if time and preservation of the material permit (additional traits are listed by Brothwell 1981). Cranial non-metric variables are preferred as cranial development is more canalised than the development of the infra-cranial skeleton. These include those variables which seem to have been most commonly recorded in the past and for which there is therefore more comparative data. There is no reason why others should not be included. It is important to remember that, at present, we have little data and thus have to assemble much larger samples (especially for prehistoric material) either from large cemeteries or by pooling data from numerous small assemblages. Initially male and female recordings should be kept separately and comparisons made. Most studies appear to indicate that data for immature individuals (although potentially not pre-pubertal material) can be combined with males and females (Hauser and De Stefano 1989, 9).

## 10.6 Research needs and potential

Fundamental research still has to be undertaken on both osteometric variation and non-metric differences, including child growth and differences in relation to environmental stress factors. Some of these areas of research have been raised by Larsen (1997) but more information needs to be gathered to answer questions such as: to what extent do food and variable chewing stresses modify jaw morphology?; does chronic stress in childhood result in smaller stature and reduced bone robustness?; do we miss small but significant variation (such as in the face)?

In the case of non-metric traits, could we score more accurately some of the traits? (for instance the oral tori). Do we give enough time to dental variables and should we include dental non-metric traits? Basic reporting is the 'bread and butter' of many who work on skeletal and dental material. It is, however, important for us to appreciate that it is only by asking questions, and giving time and thought to the problems, that progress will continue to be made in the field of metric and non-metric recording and analysis. Dental non-metric traits may also be scored following the Arizona State University methodology (described in Turner II *et al* 1991) providing that a set of comparative casts of the traits is available. There is little comparative dental non-metric data available for British skeletal populations.

*Table 1 Craniometric and mandibular dimensions: a primary listing*

| Howells code[1] | Biometrika symbol[2] | Buikstra & Ubelaker number[3] | Description |
|---|---|---|---|
| GOL | L | 1 | Greatest cranial length, from glabella, in median sagittal plane |
| XCB | B | 2 | Maximum cranial breadth perpendicular to median sagittal plane |
| BBH | H' | 4 | Basion to bregma height |
| BNL | LB | 5 | Basion to nasion direct length |
| BPL | GL | 6 | Facial length from basion to prosthion |
| NPH | G'H | 10 | Upper facial height from nasion to prosthion |
| FMB | | 12 | Upper facial breadth, breadth across the frontal bone between frontomalare anterior on each side (ie most anterior point on fronto-malar suture) |
| FRC | S'1 | 19 | Frontal chord, direct length from nasion to bregma |
| PAC | S'2 | 20 | Parietal chord, direct length from bregma to lambda |
| OCC | S'3 | 21 | Occipital chord, direct length from lambda to opisthion |
| ZMB | GB | 3 | Bizygomatic breadth, breadth from one zygomaxillare anterior to the other |
| NLB | NB | 14 | Distance between the anterior edges of the nasal aperture at its widest extent |
| NLH | NH' | 13 | Nasal height, average height from nasion to the lowest point on the border of the nasal aperture on either side |
| OBH | O2L | 16 | Orbit height, left, height between the upper and lower borders of the left orbit, perpendicular to the long axis of the orbit and bisecting it |
| OBB | O'1 | 15 | Orbit breadth, left, breadth from ectoconchion to dacryon approximating longitudinal axis bisecting the left orbit |
| EKB | | 17 | Biorbital breadth, distance from one ectoconchion to the other |
| | G'1 | 8 | Palate length, direct distance from prosthion to alveolon |
| MAB | | 7 | External palate breadth, maximum breadth across the alveolar border of the maxilla measured on lateral surfaces at M2 |
| | GoGo | 28 | Bigonial breadth/width, direct distance between left and right gonion |
| | W1 | 29 | Maximum bicondylar breadth, direct distance between two most lateral points on the two condyles |
| | | 33 | Mandibular corpus length, distance of the anterior margin of the chin from a centre point on the projected straight line placed along the posterior border of the two mandibular angles |
| | RB' | 30 | Minimum ramus breadth, least breadth of the mandibular ramus measured perpendicular to the height of the ramus |

[1]Brothwell (1981), [2]Howells (1989), [3]Buikstra and Ubelaker (1994)

*Table 2 Postcranial dimensions: a primary listing*

| ID code | Brothwell code[1] | Buikstra & Ubelaker number[2] | Bräuer/Martin & Saller number[3] | Description |
|---|---|---|---|---|
| XLF | FeL1 | 60 | 1 | Maximum femoral length, distance from the most superior point on the femoral head to the most inferior point on the distal condyles |
| STF | FeD1 | 64 | 10 | Subtrochanteric antero-posterior (sagittal) diameter of the femur, distance between anterior and posterior surfaces at the proximal end of the diaphysis (avoiding gluteal lines and/or tuberosities) |
| TTF | FeD2 | 65 | 9 | Subtrochanteric transverse diameter of the femur, distance between medial and lateral surfaces at the proximal end of the diaphysis (avoiding gluteal lines and/or tuberosities) at the point of its greatest lateral expansion below the lesser trochanter |
| WBF | FeE1 | 62 | 21 | Femoral bicondylar breadth, distance between two most laterally projecting points on the epicondyles |
| LCT | | | 1a | Complete tibial length, from the superior articular facet of lateral condyle to the most distal point of the medial malleolus |
| XLT | TiL1 | 69 | 1 | Maximum tibial length, from the most superior point on the intercondylar eminence to the most distal point of the medial malleolus |
| XLH | HuL1 | 40 | 1 | Maximum humeral length, direct distance from the most superior point on the humeral head to the most inferior point on the trochlea |
| SHH | | 42 | 10 | Sagittal (vertical) diameter of the humeral head, distance between the most superior and inferior points on the border of the articular surface |
| WDH | | 41 | 4 | Humeral epicondylar breadth, distance of the most laterally protruding point on the lateral epicondyle from the corresponding projection of the medial epicondyle |
| XLR | RaL1 | 45 | 1 | Maximum radius length, distance from the most proximal point on the head to the tip of the styloid process |
| XLU | UlL1 | 48 | 1 | Maximum ulna length, distance from the most superior point on the olecranon to the most inferior point on the styloid process |
| XLG | FiL1 | 75 | 1 | Maximum fibula length, distance from the most superior point on the fibula head to the most inferior point on the lateral malleolus |

[1]Brothwell (1981), [2]Buikstra and Ubelaker (1994) [3]Bräuer (1998) Martin & Saller (1957)

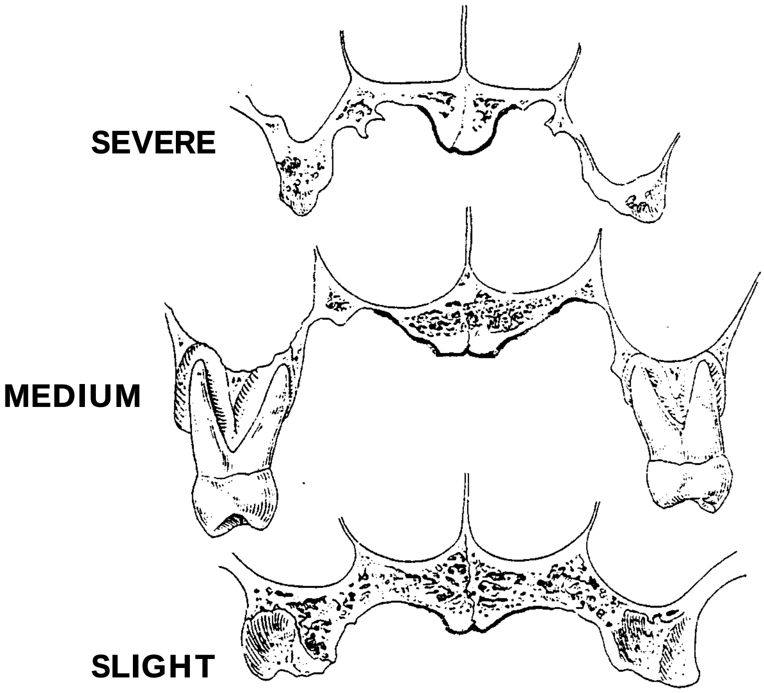
*Table 3 Cranial non-metric traits: a primary listing*

| Trait | Recording Notes |
|---|---|
| Metopism | Except in young infants, record even when nearly obliterated |
| Epipteric bones | Left & right |
| Coronal wormian bones | Left & right |
| Sagittal wormian bones | |
| Lambdoid wormian bones | Note numbers (very variable) |
| Parietal notch bones | Left & right |
| Bregmatic ossicle | |
| Asterionic bones | Left & right |
| Apical bone | |
| Occipito-mastoid suture ossicles | Left & right |
| Palatine torus | Note development as none to slight, moderate or extreme (see Figure 10) |
| Maxillary torus | Note development as none to slight, moderate or extreme (see Figure 10) |
| Parietal foramen | Left & right, present or absent |
| Infraorbital forame | Left & right, single or multiple |
| Mastoid foramen exsutural | Left & right |
| Fronto-temporal articulation | Left & right |
| Hypoglossal canals | Left & right, note as single, single with partial bridge or spine, double or multiple |
| Auditory exostosis | Left & right, present or absent and development (see Figure 11) |

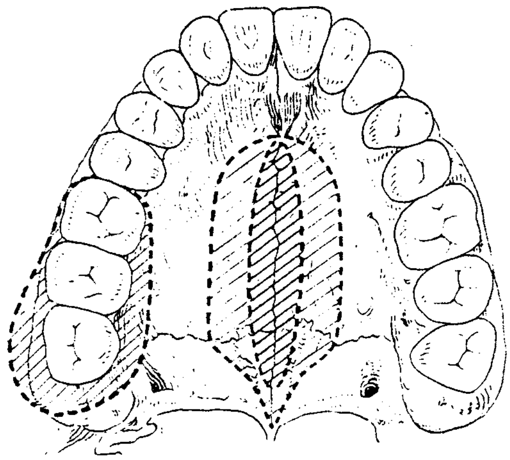
Although the presence / absence of auditory exostoses, palatine & maxillary tori are included here, all are generally considered to have a functional (rather than inherited) aetiology.

*Table 4 Postcranial non-metric traits: a primary listing*

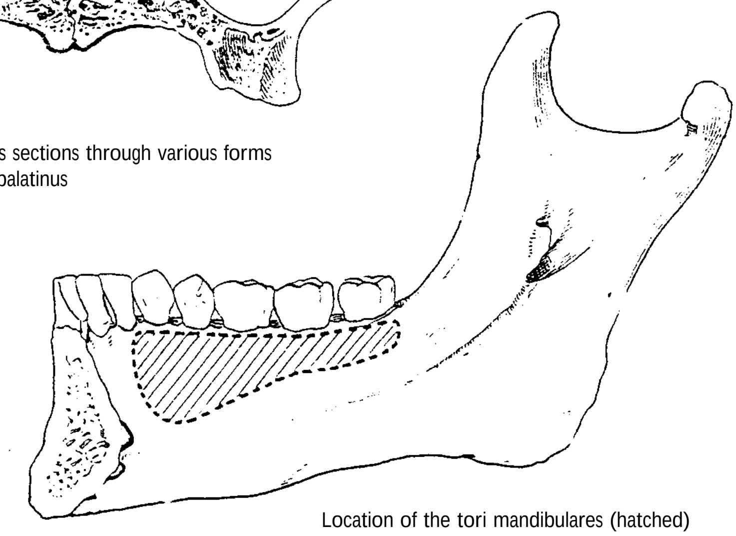
| Trait | Recording Notes – record left & right separately |
|---|---|
| Femoral plaque | Note when bone overgrowth or bony scar can be defined extending from articular surface of femoral head towards anterior portion of femoral neck |
| Tibial squatting facets | Note medial or lateral expansions of the distal articular surface onto the anterior aspect of the metaphysis. May be congenital rather than activity-related in origin |
| Distal septal aperture | Note degree of expression as absent, pinhole or true perforation or the humerus. Relatively uncommon in European populations |
| Suprascapular foramen | Note presence as suprascapular notch (most common), partially bridged or complete bridging to form foramen |
| Vastus notch present | Note presence as facet or smooth but sharp-edged notch at supero-lateral aspect of patella |
| Superior atlas facets | Note facet shape as either single (ie long & oval) or double (with two separate facets having either a groove or a ridge of bone between them) |
| Posterior atlas bridge | Note bridging of posterior aspect of superior articular facet aspect to posterior arch as absent, partial or complete |
| Accessory transverse foramina in cervical vertebrae | Note as absent, partial or complete in all cervical vertebrae |



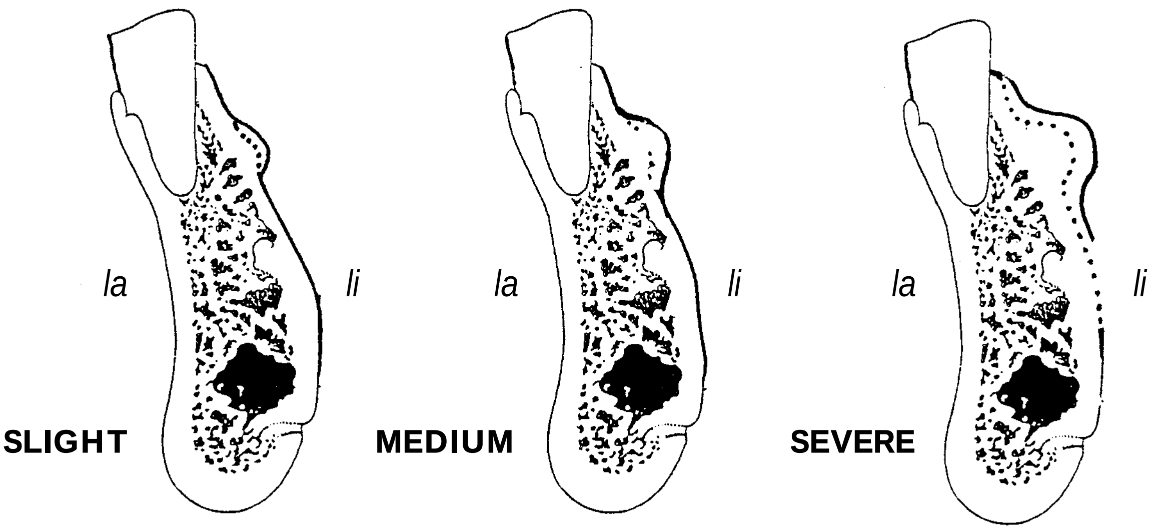

Three cross sections through various forms of a torus palatinus



Location of the tori maxillares and the torus palatinus



Location of the tori mandibulares (hatched)




The tori mandibulares vary considerably

*Figure 10  Position and development of oral tori, la = labial, li = lingual*

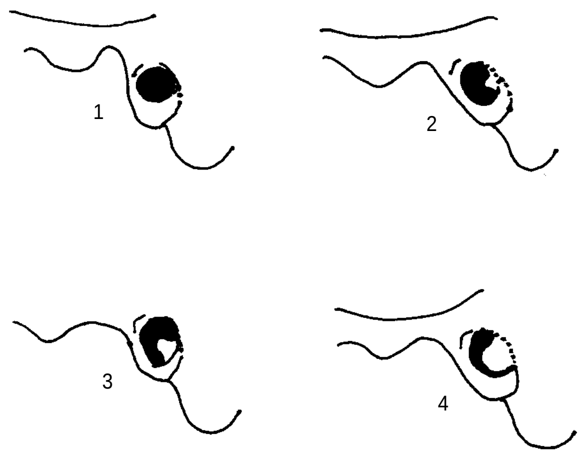



*Figure 11 Stages in the development of auditory tori*

1. *Normal external auditory meatus*
2. *Slight posterior wall increase*
3. *Moderate development of a torus*
4. *Severe stage of torus growth*

## 10.7 Stature estimation

Growth is an individual characteristic (Malina and Bouchard 1991) but can only be studied archaeologically in terms of samples. Stature is an inherent characteristic reflecting both genetic predisposition, and childhood periods of environmental and social stresses (including childhood health and nutrition). The estimation of stature from the length of long bones, therefore, can be an important part of any osteological analysis.

Stature is obviously affected by sex, age and posture, but is also linked to repetitive activities and occupation etc. The prediction equations usually employed and recommended here were derived from US samples (Trotter 1970; Trotter and Gleser 1952; 1958; 1977) and thus may not always be suitable for British samples (Table 5). It is vital not to estimate stature by computing the mean of the results from all stature prediction equations as this increases the errors associated with the equations. Lower limb bones give stature estimates with smaller associated errors and thus those equations should be preferred when many long bones are present. It is useful when first calculating stature estimates to use all the potential equations to see whether the *spread* of results is greater using the *white* or the *black* equations as these relate to body shape rather than 'race'. Equations should then be used preferentially in descending order (as they are displayed in terms of increasing associated error). It must be remembered that stature predictions are only estimates of stature and as such have errors associated with them. Any data analysis should therefore concentrate upon using the raw long bone lengths rather than predicted statures (with their associated errors).

*Table 5: Stature prediction equations, displayed in order of preference (see Table 2 for code key)*
*Note that the long bone measurements must be in cm (NOT mm)*

| Males | |
|---|---|
| *American Whites* | |
| 1.30 (XLF + LCT) + 63.29 | ± 2.99 |
| 2.38 XLF + 61.41 | ± 3.27 |
| 2.68 XLG + 71.78 | ± 3.29 |
| 2.52 LCT + 78.62 | ± 3.37 |
| 1.31 (XLF + XLG) + 63.05 | ± 3.62 |
| 3.08 XLH + 70.45 | ± 4.05 |
| 1.82 (XLH + XLR) + 67.97 | ± 4.31 |
| 3.70 XLU + 74.05 | ± 4.32 |
| 3.78 XLR + 79.01 | ± 4.32 |
| *American Blacks* | |
| 1.15(XLF + LCT) + 71.04 | ± 3.53 |
| 1.20 (XLF + XLG) + 67.77 | ± 3.63 |
| 2.19 LCT + 86.02 | ± 3.78 |
| 2.10 XLF + 72.22 | ± 3.91 |
| 2.34 XLG + 80.07 | ± 4.02 |
| 1.66 (XLH + XLR) + 73.08 | ± 4.18 |
| 1.65 (XLH + XLU) + 70.67 | ± 4.23 |
| 2.88 XLH + 75.48 | ± 4.23 |
| 3.42 XLR + 81.56 | ± 4.30 |
| 3.26 XLU + 79.29 | ± 4.42 |

| Females | |
|---|---|
| *American Whites* | |
| 0.68 XLH + 1.17 XLF + 1.15 LCT + 50.12 | ±3.51 |
| 1.48 XLF + 1.28 LCT + 53.07 | ± 3.55 |
| 1.39 (XLF + LCT) + 53.20 | ± 3.55 |
| 2.93 XLG + 59.61 | ± 3.57 |
| 2.90 LCT + 61.53 | ± 3.66 |
| 1.35 XLH + 1.95 LCT + 52.77 | ± 3.67 |
| 2.47 XLF + 54.10 | ± 3.72 |
| 4.74 XLR + 54.93 | ± 4.24 |
| 4.27 XLU + 57.76 | ± 4.30 |
| 3.36 XLH + 57.97 | ± 4.45 |
| *American Blacks* | |
| 0.44 XLH – 0.20 XLR + 1.46 XLF + 0.86 LCT + 56.33 | ± 3.22 |
| 1.53 XLF + 0.96 LCT + 58.54 | ± 3.23 |
| 1.26 (XLF + LCT) + 59.72 | ± 3.28 |
| 2.28 XLF + 59.76 | ± 3.41 |
| 2.45 LCT + 72.65 | ± 3.70 |
| 2.49 XLG + 70.90 | ± 3.80 |
| 3.08 XLH + 64.67 | ± 4.25 |
| 3.31 XLU 75.38 | ± 4.83 |
| 2.75 XLR + 94.51 | ± 5.05 |

# 11 Guidance on recording palaeopathology

*Charlotte Roberts and Brian Connell*

'Few published data sets were directly comparable (and) ... no single report offered comprehensive data' (Rose in Buikstra and Ubelaker 1994, 3).

## 11.1 Introduction

The science of biological anthropology encompasses many different disciplines and one of the major themes within the discipline is the study of patterns of disease in past populations (palaeopathology). Studies in palaeopathology have gradually shifted away from singular case study approaches towards viewing biological data in a wider cultural context (eg Jurmain 2001), with Europe following closely with this North American tradition. While there are many different types of evidence for considering health in past populations, including historical and iconographic representation, human remains from archaeological sites provide the primary source of data.

Mays (1997; 1998) has noted the emergence of broader synthetic work and suggests that studies of human remains should be directed at understanding specific archaeological problems, in addition to pursuing particular themes about the past and / or testing hypotheses. One key area of this exercise involves examining the role that disease has played in the complex process of adaptation of human groups to their environment (Ortner 1991). This should potentially allow us to consider the population dynamics of disease and to investigate patterns and trends in human biocultural adaptation in the past. It is important that future studies in palaeopathology are underpinned by having comparable data sets that allow inter-population comparisons. The mechanism by which this can be achieved is by establishing a commonly accepted set of standard methods for basic skeletal and dental pathology recording. Human bone reports undertaken as part of commercial projects are vital in providing data for future investigations.

The standardisation of pathology data recording is by no means a straightforward exercise. It is difficult to encourage different researchers (with different agenda and commitment to the study of palaeopathology) to agree which data should be recorded and why. The quality and quantity of data recorded still varies considerably and, as Larsen (1997, 340) points out, the standardisation of data collection from human bones remains a complex issue. Stimulated by the prospect of repatriation of human remains and their reburial in North America in the late 1980s, the first steps towards standardisation of recording in palaeopathology were taken by Rose *et al* (1991) who suggested a series of objective criteria based on description. This was followed by a more comprehensive set of recommendations made by Buikstra and Ubelaker (1994). The latter currently stands as the most commonly accepted set of standards and forms the basis for the present (BABAO) document. While reburial of skeletal material in the UK is not (currently) the stimulus to this document, it could be relevant in future years. Despite this, studies of health and disease in past British populations need to establish recommendations for recording of data in order that the discipline of palaeopathology advances and becomes more scientifically valid.

The aim of this section is to:

- Review the methods currently in use for recording pathological lesions in human skeletal remains
- To make some recommendations for guidance of those working in palaeopathology. This is particularly important for projects where time and money may be limited

## 11.2 Recording of pathological lesions: the language of description

'Accurate and comprehensive descriptions of pathological lesions are necessary for accurate diagnoses and also permit other researchers to evaluate proposed diagnoses' (Lovell 2000, 219).

Ortner and Putschar (1985, 36) suggest that there are three essential elements for recording skeletal pathology:

1. Unambiguous terminology
2. Precise identification of the position of lesions in abnormal bones / teeth
3. Descriptive summary of the morphology of abnormal bones / teeth

The basic premise for recording of pathological lesions should be a detailed description of abnormal lesions, prior to any suggestion of diagnosis. In undertaking this primary description, the language must be simple and non-technical, and if any technical terms are used then they should be clearly defined. Buikstra and Ubelaker (1994, 108) stress the importance of clear, consistent and unambiguous terminology and the hazards associated with the use of non-standard terminology. In order to obtain some form of acceptable standard terminology, the terms suggested by Lovell (2000, 221) could be used as a baseline. As Buikstra and Ubelaker (1994, 107) state, 'the goal of the following data collection protocol is not to lead the observer to a specific disease diagnosis, but rather to encourage data collection sufficient for future scholarship...'.

Lovell (2000, 219) suggests that due consideration should be given to: appearances of pathological lesions, their position on a skeletal element, and the distribution of lesions in the skeleton and the population from which it derives. The description of pathological bone changes based on visual observation is, for most, a macroscopic exercise. However, it is recommended that descriptions are supported with low-power microscopic examination (eg x10) and X-radiography wherever possible (see Section 2.4).

The following is suggested as a step by step procedure in description. It should be noted that comparison of abnormal with normal elements is a pre-requisite to recognising the abnormal, and access to a comparative skeleton is considered essential for this work (and a good knowledge of the normal appearance of the bone or tooth). Only definite abnormalities should be recorded so as not to over-inflate prevalence rates for disease (ie avoid recording normal variation as disease):

- i Which bone / tooth is affected (including side).
- ii What part of the bone / tooth (eg proximal shaft), and aspect (eg medial) is involved, using anatomical terms (also see Lovell 2000, table 8.2 for terms).
- iii What is the nature of the lesion itself (see Lovell 2000, table 8.1 for terms)? Is it a forming, destroying or mixed lesion?
- iv If bone has been formed, is it woven (porous, disorganised and indicating active disease at the time of death) or lamellar (smooth and organised), indicating a healed and chronic lesion, or is it in the process of healing? See Figures 12 and 13.
- v If bone has been destroyed, is there any sign of healing eg rounding of the edges of the lesion (see Figure 14).
- vi What is the distribution pattern of the lesions if more than one bone / tooth is involved? Different disease processes have different patterning (for example, leprosy affects the facial, hand and foot bones).
- vii Can the abnormality be measured and compared with the normal opposite side?
- viii Consider all potential diagnoses for the abnormalities recorded (differential diagnosis).

*Figure 12 Woven new bone formation (arrowed) on visceral surfaces of ribs*

*Figure 13 Lamellar new bone formation (arrowed) on long bone shaft*

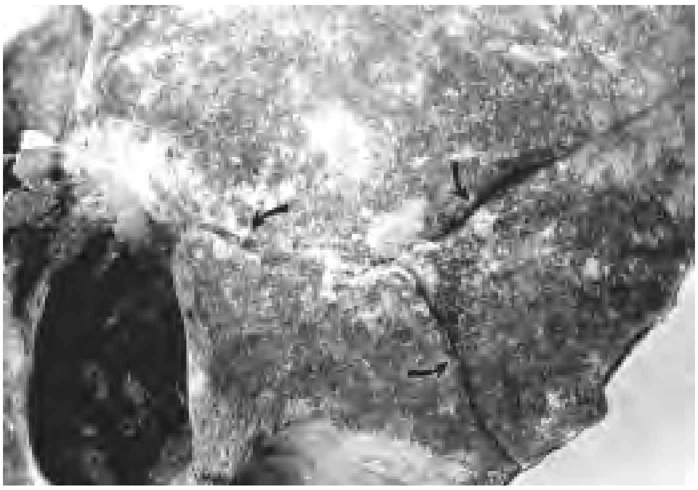


*Figure 14 Healed injury to left frontal vault; arrows show healed fracture lines*

It is absolutely essential that any description thus given should allow for independent review by another observer who can, based on an objective description, agree or disagree with the preferred diagnosis. This should also help ensure comparability across samples and between populations.

Photographs of abnormal or rare lesions are recommended, especially if they are unusual and a diagnosis made is rather tenuous; this will help other researchers when the abnormalities are being reconsidered. Photographs should also be taken if the severities of lesions are being described. Scales should be used and preferably a normal bone or tooth as a comparison (opposite if appropriate and present). Black backgrounds are often an effective contrast for displaying bones and their lesions. Filling most of the frame with the bone often provides a more informative illustration (Cover, upper left Figure). When X-radiography is used, descriptions should include the relationship of the lesion to the underlying cortex, any endosteal changes and / or changes in the medullary cavity.

## 11.3 Coding of lesions

Buikstra and Ubelaker's (1994) extensive and detailed recording system of individual bone and pathology codes followed by side, section and aspect, followed again by more coding of pathology, is far too cumbersome and restrictive to be of practical use in most cases (especially in contract archaeology). For example, a right ulna with a healed parry fracture would be coded as follows: (1), (3), (9), (4.1.3), (5.1.3). These aspects of the lesion / pathology should already have been covered in the descriptive process and the codes do not represent quantitative data. Osteologists might get too involved with sorting out codes rather than focusing on clear unambiguous description.

## 11.4 Problems and limitations

When an osteologist examines a skeleton that displays pathological alteration one of the problems faced is the level of accuracy associated with a 'diagnosis', which can often be limited due to the absence of soft tissue or the inability to apply immunological tests (Pfeiffer 1991; Waldron 1994). The recent developments in the use of microbial ancient DNA and other biomolecules to diagnose disease has been a major development in palaeopathology (eg see Salo *et al* 1994), despite the inherent methodological problems. In addition, a positive result for a particular pathogen's ancient DNA does not necessarily mean that the bone changes were caused by that disease. Nevertheless, for those with access to these types of analyses there are clear advantages. However, sampling for ancient DNA and other biomolecules for disease diagnosis should only be undertaken when a full osteological analysis of the skeleton concerned has been undertaken. The possibility that DNA may not be preserved should also be considered. Further information on bone chemistry can be found in Section 13.

Because reaching a secure diagnosis is often very difficult, some workers advocate interpreting all data from a clinical base (eg Roberts and Manchester 1995), and a good recommended reference is Resnick (1995). Others are more cautious with this approach and Ortner (1991, 6) warns against an over-reliance on clinical diagnostic criteria. Miller *et al* (1996) have pointed out that only areas of the skeleton with obvious pathological changes are radiographed, or that surgically derived specimens might represent a milder expression of a serious disease than would be found in those individuals without access to medical intervention. These factors limit the palaeopathological usefulness of descriptions of diseases in modern clinical literature (Miller *et al* 1996, 224). Other problems may arise from the fact that many of the more subtle changes apparent on a dry-bone specimen will not be part of the experience of the radiologist, and thus not be part of the radiological descriptive and classificatory system (Ortner 1991, 8). Clearly, some clinical diagnostic criteria are not appropriate for archaeologically derived skeletal material and some changes seen in skeletal remains may not be noted clinically eg bone formation on ribs or in the maxillary sinuses. It is clear that, whatever the case, clinical comparisons should be chosen with caution. It is appropriate to suggest that the use of clinical data from developing countries (the most analogous to an archaeological context) may be more useful in this respect. The manifestation of disease in bone will not necessarily have been altered by the influence of drug therapy (ie untreated), for example, and environmental and sociocultural factors may be similar. Despite these problems the only way to attempt any form of classification or diagnosis of disease in skeletal material is with clear and objective description. It is only with this base description that potential diagnosis can be made.

Two further points need noting here. Firstly, researchers should be aware of the possible effects of burial in the ground on the integrity of skeletal remains (taphonomic factors, see Section 5.3.2), and the possibility that abnormal changes to bones and teeth may be the result of post mortem damage such as root marks, rodent gnawing, deformation through soil pressure in the grave, and erosion from the soil (Figures 6–8; Buikstra and Ubelaker, 1994 figures 68–73). In addition, pseudopathological lesions may be confused with normal features of the skeleton such as Pacchionian pits on the endocranial surface of the skull, normal blood vessel markings (knowledge of normal anatomy here is essential), new bone formation as a result of the normal growth and remodelling processes in bones of juveniles, and the presence of non-metric traits. Secondly, researchers should note that, as bone tissue can only react in a limited number of ways to a disease stimulus (form / destroy bone), there can be several different processes that could potentially induce the observed result and these must be given full consideration in the differential diagnosis.

## 11.5 Specific disease processes

It has been stressed that detailed descriptions of pathological lesions are essential. These descriptions and / or potential diagnoses should be supported using the most up to date and appropriate literature. There are several well-established methods for recording and describing the more commonly encountered disease processes in archaeologically derived human bones; these are covered in Section 11.7.

## 11.6 Congenital and developmental abnormality

Barnes (1994) gives an excellent summary of most of the congenital / developmental defects that occur in the axial skeleton, such as border shifts (eg L5 sacralisation, S1 lumbarisation, C1 occipitalisation), segmentation errors (eg hemivertebrae, segmentation failures (fusion)) and developmental defects (eg spina bifida occulta, hypoplasia, aplasia etc). Turkel (1989) is also useful.

## 11.7 Specific disease processes

### 11.7.1 Infectious disease

All bone changes attributed to infection should clearly state the extent to which the bone affected is involved in *non-specific infection*, eg periostitis, osteomyelitis (presence of cloaca – sinus or hole, sequestrum – dead bone, and involucrum – new sheath of bone) and osteitis. Specific areas of the skeleton should be noted for non-specific infection: maxillary sinuses if broken post mortem and therefore visible (use Boocock *et al* 1995 classification), ribs (see Roberts *et al* 1994), and the endocranial surface of the skull.

*Specific infections* (treponemal disease, tuberculosis, leprosy) should clearly state which diagnostic criteria have been used. We would recommend the following in addition to Ortner and Putschar (1985) and Aufderheide and Rodríguez-Martín (1998):

- Leprosy: Anderson *et al* (1992; 1994), Anderson and Manchester (1987; 1988; 1992), Rogers and Waldron (1989), Lewis *et al* (1995)
- Tuberculosis: Rogers and Waldron (1989)
- Treponemal disease: Hackett (1976), Rogers and Waldron (1989)

### 11.7.2 Trauma

#### 11.7.2.1 Fractures

Record:

- bone affected
- part of bone
- type of fracture (spiral, comminuted, transverse, oblique, greenstick, compression (eg vertebrae), depressed (eg cranial)
- the probability of it being simple or compound
- angular or spiral deformity
- apposition of the fracture fragments
- amount of overlap
- evidence of healing
- evidence of complications, eg non-union, pseudoarthrosis, necrosis or death of bone, secondary complications such as infection and joint disease – care in determining whether pre- or post-fracture

Lovell (1997) is also useful. For recording radiographs of fractures see Roberts (1988).

#### 11.7.2.2 Dislocation

Record joint affected and any changes to the joint surfaces, including a new joint surface development; is the dislocation congenital or traumatically induced? Any associated fractures?

#### 11.7.2.4 Soft tissue injury

Record area of bone affected and link to muscle (myositis ossificans), tendon / ligament attachments and actions.

#### 11.7.2.4 Other

Separation of the neural arch of the lumbar vertebra (usually L5) or spondylolysis; with or without slipping forward of the vertebra (spondylolisthesis); is it unilateral or bilateral, are there any other associated defects, and is there any evidence of healing?

*Amputation*: element affected, any evidence of healing, any evidence of difference in size of bones affected and not affected (disuse)

*Trepanation*: type (scrape, saw, bore and saw, gouge, drill), position on the skull, healed or not, any evidence for head injury.

*Autopsy*: for craniotomy record angle, position and precision of saw cut (number of attempts) and whether occipital bone is included in the seat, or merely the frontal and parietal sectors. For sawn long bones, if possible, a distinction should be made between possible practice amputation and evidence for anatomical specimen preparation.

### 11.7.3 Joint disease

Joint disease is one of the more common pathological conditions found in skeletal remains. This is mostly osteoarthritis, but erosive lesions are also found (inter-articular and para-articular). Osteoarthritic changes should be recorded by joint location. The work of Rogers and Waldron is particularly useful here and it is recommended that these diagnostic criteria are used (Rogers *et al* 1987; Rogers and Waldron 1995).

*Osteophytes* or new bone formation on and around joint margins. It is important to describe the type of osteophytes that have formed at joints, because different types are associated with various conditions (refer to Rogers and Waldron 1995, table 3.1). It should also be noted that in British skeletal populations, the formation of bone appears to be common at tendon, ligament and muscle attachment sites ('bone formers'); this should not be confused with bone formation as a result of activity. *Porosity, subarticular* (subchondral) *cysts* (usually only seen on radiographs), *eburnation* (polishing), fusion at joints, and *Schmorl's nodes* (depressions only in the vertebral body surfaces) should be recorded at the vertebral level. For joint disease in vertebral bodies and apophyseal facets (porosity, osteophytes and eburnation) the grading scheme of Sager (1969) should be used; it is essential to record the specific vertebrae and joints affected. It is recommended that the different changes of joint disease should not be 'lumped' together to indicate severity, because an increase in the extent of one feature may not necessarily be paralleled by an increase in extent of another. Specific conditions such as gout, septic arthritis, ankylosing spondylitis and diffuse idiopathic skeletal hyperostosis may be considered using the criteria of Rogers and Waldron (1995; 2001). Erosive lesions, away from, on or around the joint should also be recorded. Severity of changes of osteophytes, porosity and eburnation should focus on Buikstra and Ubelaker (1994, 123).

If osteoarthritis is being used as a possible indicator of lifestyle / occupation, other indicators such as enthesophytes (tendon and ligament attachments), differences in the size of left and right bones, other pathological lesions and some non-metric traits should also be considered (see Jurmain 1999). Osteoarthritis should never be used alone as an indicator of occupation because of its multifactorial aetiology.

### 11.7.4 Metabolic disease

For *cribra orbitalia* grading follow Stuart-Macadam (1991).
For *scurvy* changes, consult Ortner and Ericksen (1997), Ortner *et al* (1999).
For *rickets* consult (Ortner and Mays 1998).
Record *osteoporosis* on the basis of spinal (cod fish vertebrae) fractures, plus loss of cortical bone and bone mass (assuming not post mortem); refer to Pfeiffer and Lazenby (1991). Radial (Colles) and neck of femur fractures may also indicate underlying osteoporosis but can be caused by other factors. Micro-callus fractures are commonly associated with osteoporosis and can be viewed using light or scanning electron microscopy (Roberts and Wakely 1992).
For *Harris Lines* record number of lines in antero-posterior radiographs and their extent across the shaft of long bones (femur, tibia, and radius are the most useful bones): be aware of the problems of identification and interpretation of Harris lines and that they resorb with age (Grolleau-Raoux *et al* 1997; Macchiarelli *et al* 1994).
For hyperostosis frontalis interna consult Barber *et al* (1997)

### 11.7.5 Endocrine disease

Endocrine disease is a rare occurrence but Aufderheide and Rodríguez Martín (1998) describe changes associated with this class of disease.

### 11.7.6 Neoplastic disease

The first step should be differentiating whether a lesion is benign or malignant. In many cases the source cell type will be almost impossible to identify. It is recommended that any skeleton with malignant changes should be radiographed as fully as possible (see Rothschild and Rothschild 1995 for the value of doing this). The most common conditions are benign ivory osteomas of the skull vault, osteoid osteomas of the long bones and solitary osteochondromas of long bones.

### 11.7.7 Dental disease

Dental disease is probably the condition that has most often been well recorded in British contexts, including the provision of absolute prevalence rates.
Lesions / defects should be recorded at the individual tooth level (for caries, calculus, enamel hypoplasia) or tooth position (for alveolar resorption, periodontal disease, periapical lesions). Information on the numerical coding of each tooth during recording is provided in Section 3. Dental anomalies should be recorded following Hillson (1996).

#### 11.7.7.1 Caries

For carious destruction of teeth the scheme of Lukacs (1989) should be used with the severity of grades of Hillson (2000; 2001). The position should be based on whether the lesion is on the crown (coronal) or on the root surface. Coronal caries should be described as occlusal, lingual, buccal / labial or on interproximal surfaces (mesial or distal), or the cervical (neck) area at the cemento-enamel junction. In advanced caries with gross destruction of the crown, the site of origin cannot be identified. Be careful not to record caries in occlusal surfaces of molar teeth which may be discoloration in the fissures due to soil. Exposure of the pulp cavity can be mistaken for caries, but may be a complication of caries.

#### 11.7.7.2 Calculus

The amount of calculus deposit can be recorded following Brothwell (1981) or Dobney and Brothwell (1987), the latter being more detailed (and the former rather subjective but easy to use). Calculus deposits should also be recorded as supra or sub-gingival.

#### 11.7.7.3 Alveolar disease

The severity of alveolar resorption is as follows (anything up to 2mm between the cemento-enamel junction and the alveolar margin can be healthy):

1 = 2–3mm
2 = 3–5mm
3 = majority of tooth root exposed.

The severity of periodontal disease could be recorded using Brothwell (1981), which is a rather subjective method but relatively easy to use. However, as the distance between the cemento-enamel junction and the alveolar bone increases with age, an additional method of recording periodontal disease would be to observe and record concavity and porosity of the inter-dental septa.

#### 11.7.7.4 Enamel hypoplasia

(hypoplastic lines, pits and grooves). Recommendations for recording:

- Type of defect: linear horizontal grooves, linear vertical grooves, linear horizontal pits, non-linear array of pits, single pits (from Buikstra and Ubelaker 1994)
- Position: 1 = cusp, 2 = middle section of crown, 3 = neck (crown of tooth divided into three sections by eye), and
- Severity: 1 = just discernible line, 2 = clear groove, 3 = gross defects
- Hypocalcifications may be recorded as yellow, cream / white, orange or brown and where they are located; post mortem discolouration due to burial in the ground may confuse recording and interpretation

To record timing of defect use Reid and Dean (2000), but be aware of the problems of recording and interpretation of these data.

#### 11.7.7.5 Periapical lesions

The location of the drainage sinus should be described (external, internal or maxillary sinus) and whether or not the lesion is associated with a carious lesion or from pulp cavity exposure due to heavy tooth wear.

#### 11.7.7.6 Ante mortem dental modifications

Follow the guidelines of Buikstra and Ubelaker (1994, 58).

#### 11.7.7.7 Other lesions

Leprogenic odontodysplasia associated with leprosy (see Roberts 1986), defects in teeth associated with congenital syphilis (see Hillson and Grigson 1998).

## 11.8 Presentation of data and interpretation

The data collected should be presented in tabular and graphical form, and by age and sex, keeping age and sex separate where sample size permits. It is particularly important to provide a table that lists the numbers of each of the individual bones and teeth present, and in the case of long bones the segment present eg proximal, mid or distal available for study. Using these data it is then possible to determine absolute frequencies of disease. Many assemblages contain fragmentary and incomplete bones, and to maintain consistency in the calculation of frequencies it is recommended that a long bone or articular surface is counted as ‘present’ where two-thirds or more is available for examination (see Section 2, and Appendices 4 and 5). It is acceptable to present data according to number of individuals affected as long as the frequency according to bones / teeth present is also given. Summary statistics are also recommended.

Note that for archaeological populations *prevalence* (proportion of the population at any one time with a specified condition) should be the term applied to frequency rates, and not *incidence* (new cases of a disease in a defined population at risk over a specified unit of time, usually expressed as $10^3$ or $10^5$) – definitions taken from Waldron (1994).

In the interpretation of the data, age, sex and (where possible) social status and their influence on the patterns of disease seen should be noted. However, remember that the disease observed may have occurred initially many years before the death of the individual, and therefore correlation of age at death and disease is usually problematic. However, most important is a consideration of the data in its cultural context so that explanations can be suggested for the disease frequencies seen. For example, is it a rural or urban site, is the population composed of hunters and gatherers or agriculturists, and do we know what their living environment was like? A consideration of social, economic and environmental factors is essential. Caution should be expressed in trying to associate skeletal changes with symptoms (see Roberts 2000) and close consideration should be paid to Wood *et al*’s (1992) recommendations on inferring health from the skeleton, and how representative the sample of skeletons are of the original living population.

# 12 Recording of weapon trauma

*Anthea Boylston*

## 12.1 Introduction

Much of the literature on this subject has appeared during the last decade and therefore additions and amendments are required to the standards upon which we base our recording methods. Weapon trauma is illustrated quite frequently in the literature but methods for its recognition and reporting are less common. Diagrams and descriptions are an essential part of this process, a good example of which is provided by the trepanation diagram and its accompanying attachment in Buikstra and Ubelaker (1994, 160). This can be adapted to illustrate other forms of cranial trauma, whether healed, healing or unhealed, by use of the skull recording forms from the same volume. The graphic illustrations of the wound should be accompanied by a written description and appropriate measurements.

Injuries can be subdivided into three main categories: sharp force, blunt force and projectile trauma, a nomenclature devised by Spitz (1980).

## 12.2 Post mortem vs peri-mortem trauma

A thorough knowledge of the taphonomic processes which affect bone after burial are required for the successful identification of trauma which has occurred before or around the time of death (Sauer 1998; Symes *et al* 2002; Saul and Saul 2002). The difference between peri-mortem and post mortem cranial fractures is well described in Buikstra and Ubelaker (1994, 103–6). If the bone fractures at a right angle the breakage is likely to have occurred after burial, possibly during machine stripping of the site prior to excavation. There is also likely to be a colour difference between new and old breaks in bone with post mortem breaks appearing ‘clean’ and lighter in colour in comparison to the rest of the bone, but care must be taken in such interpretation. Brittle bone also has a tendency to break into a number of pieces. By contrast, wounds occurring around the time of death often produce an oblique pattern. Sauer (1998) described in detail the differences between ante mortem, peri-mortem and post mortem trauma.

## 12.3 Sharp force trauma

Cut marks from edged weapons are quite easy to identify, both on the skull and on postcranial bones. The nature of the cut depends on whether the weapon has: (1) passed cleanly through the bone; (2) come in contact with it and glanced off; (3) made contact and produced a deeper wound (sometimes removing a roundel of bone which may traverse both outer and inner tables or just penetrate the diploe); or (4) merely created an incised wound, sometimes known as a skip lesion (Novak, *pers comm*). The soft tissues would have held the bones together at the time of interment, only for them to fall apart in the burial environment. So there may be taphonomic variability with colour differences between separated pieces. This should be carefully recorded.

The first category of injury, where the blade has passed cleanly through bone, will produce a wound with straight, clean-cut edges which may be almost perpendicular with the bone surface. These lesions can be seen clearly on the cranium (Cover, centre right Figure) and occasionally on the postcranial bones, eg if a limb is amputated with a sword in battle. There may also be terminal fractures at the end of a cranial wound. The second category will produce a gutter fracture where the sword has grazed the bone. By contrast, in the third scenario the diagnostic criteria are more complicated (Figure 15) and consist of:

- a linear wound with a well-defined clean edge
- a flat, smooth, polished cut surface on the oblique side of the injury
- flaking and roughening on the acute side
- the possibility of terminal fractures

Finally, incised wounds will create a linear cut which may have small flakes of bone chipped off its edges.

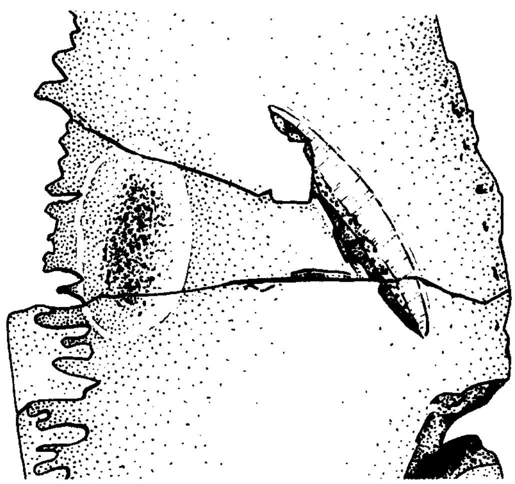


*Figure 15 Late Anglo-Saxon skull from Addingham (105) with two sharp weapon wounds; the left-hand one is shallow and has a scooped appearance, penetrateing the cancellous bone of the diploe. The right-hand injury has a smooth edge on its oblique surface and flakes on the acute edge where the blade was halted by its contact with bone (illustration by Caroline Needham).*

In addition to individual diagrams, it is important to produce composite diagrams of all the wounds in an assemblage in order that any patterns to the trauma may become apparent (Stroud and Kemp 1993; Novak 2000). The majority of cranial injuries occur on the left side of the skull as a result of face-to-face combat between right-handed participants. However, in the front line of battle, injuries can be delivered to any part of the head and often concentrate on particular postcranial bones, eg defence wounds on the forearms or hand bones. The direction from which the cut has been delivered may be discernible from studying the angle at which the weapon connected with the bone.

Scanning electron microscopy may assist with a detailed investigation of the nature of the injury and with matching it to a particular weapon. In addition, radiographic analysis could identify small pieces of metal adhering to the wound.

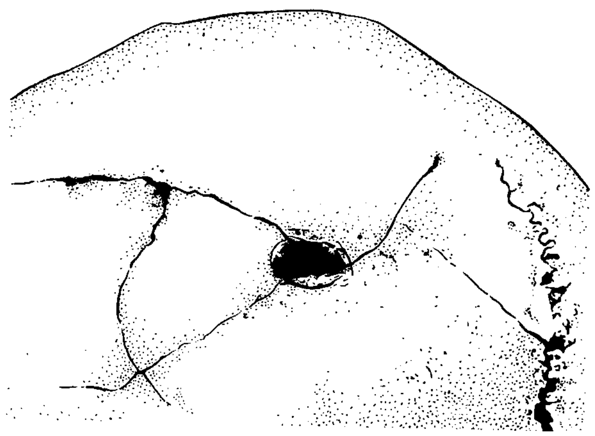


*Figure 16 Blunt force injury showing concentric fractures surrounding the point of impact and radiating fractures leading towards it. Note the flakes adhering to the edges of the wound. ('The Jerusalem skull' published by permission of Dr Kay Prag and illustation by Caroline Needham).*

## 12.4 Blunt trauma to the cranium

The biomechanics of the skull affect the way in which it responds to injury with a blunt weapon (Berryman and Symes 1998). The outer table of the cranium comes under compression and the inner table under tension (except in the case of a projectile exit wound when the situation would be reversed). If the force of the blow exceeds the elastic limit of the bone, the inner table fractures in the immediate area of the blow forcing a cone of bone to break away from around the entrance wound. The outer table is more likely to separate in a concentric fashion around the affected region. A recent study of blunt force trauma in both cranial and postcranial elements gives, in great detail, the types of fractures that can occur in response to this type of injury (Galloway 1999).

Blunt trauma should be recorded by:

- Stating the type of fracture, eg depressed (pond), depressed (stellate), depressed (comminuted), expressed, etc
- Attempting to identify the point of impact
- Describing (with illustrations) the presence of concentric or radiating fractures
- Identifying whether there is internal bevelling
- Looking at the edges of the wound to see if there are any flakes of bone adhering to them since in fresh bone the flakes tend to remain attached (Figure 16)

If there was more than one blow, it may be possible to tell which of them was delivered first by studying the intersection of the radiating fractures from each blow (Madea and Staak 1988). The Iron Age site of Danebury produced many examples of such trauma, in addition to injuries to postcranial bones (Hooper 1984).

## 12.5 Projectile trauma

This type of trauma includes injuries produced by slow-moving weapons as well as wounds caused by missiles like arrows and bullets. Indeed, differences in velocity of the projectile may produce varying patterns in the affected cranium (Berryman and Symes 1998). Such wounds may be distinguished from other holes in the cranium by the diagnostic criteria of Kaufman *et al* (1997).

It is important to record:

- The size and shape of the hole
- Whether the bevelling is internal or external (as on the exit wound from a gunshot)
- Whether there are radiating fractures and their extent
- The appearance of the perimeter of the hole created by the weapon (are there adherent flakes or peeling)

## 12.6 Healed lesions of the cranium

Healed injuries from edged or blunt weapons are denoted by rounding of the edges of the wound. Sledzik and Barbian (1997) described the sequence of events which characterise the early healing process in cranial injuries from people with known medical histories. The earliest visible change is denoted by rounding of the cut edge of the bone at the site of the wound. This commences between one and two weeks after the injury has occurred. Once an injury has healed completely it is very difficult to estimate the interval between its occurrence and the demise of the individual. It is important to record the extent of the injury, the bone or bones affected and the extent of the healing process. Is callus still present or has the bone completely remodelled?

Healed depressed fractures are quite often described in the archaeological record. They are often quite small and commonly occur on the frontal bone. If a roundel of bone is removed by an edged weapon and healing has taken place, it may be very difficult to differentiate the end result from a healed trepanation. However, trepanations are quite often found in association with healed cranial injuries and may indicate that treatment of a head wound has been attempted, in some cases quite successfully (eg Wells 1982).

## 12.7 Postcranial injuries

Postcranial sharp force injuries which took place around the time of death may be recognised by identification of cut marks on bone but can be difficult to distinguish from pseudopathology if the characteristic polishing is not present. Perimortal blunt force trauma to the long bones may produce the classic 'butterfly' fracture, but this has also been described in a case of post mortem breakage (Ubelaker and Adams 1995). White (1992) illustrated the changes which are characteristic of perimortal fracture in the postcranial skeleton. These consist of:

- peeling
- flaking
- spiral fractures

Twig peel affects the surface of the bone and gives it the ridged appearance of an iced-lolly stick that has been broken in two pieces (Novak *pers comm*). Flaking can often be seen on the edge of the wound and spiral fractures produce a straight edge, with no post mortem fraying, that follows the contours of the bone. These changes are often most clearly seen on faunal remains where the bones have been struck for the purposes of bone marrow extraction (Figure 17). It is a good idea for the human osteologist to familiarise him / herself with the appearance of bone which has been the object of such practices.

## 12.8 Decapitation

Recording of decapitated skeletal remains is relatively straightforward if it is clear that the head was removed prior to burial. However, sometimes the cervical vertebrae have been severed but the skeleton is in normal alignment. Ritual decapitation was practised both during the Romano-British and Anglo-Saxon periods in England and in 1981 Harman *et al* assembled all the information on decapitations published up to that date. They also determined that decapitation often took place from the front. McKinley (1993) described in detail decapitation in a particular individual from Roman Baldock.

Cut marks should be sought on both the anterior and posterior aspects of the vertebrae, where initial attempts to sever the head may have struck bone, as well as recording the transverse slices which remove a section of the vertebral body or neural arch. It may be possible to determine whether the injury was delivered from the right or left side by the angle of the cut. Quite often the neural arch is split, much in the way that a piece of fresh wood will break.

It is also important to examine the mandible carefully since decapitation quite often results in cuts on this bone. In one case, a decapitation at the base of the neck had resulted in an injury to the clavicle (Boylston *et al* 2000). It is, therefore, important to describe which vertebrae are affected and to relate this information to cultural practices which operated at the period in question.

## 12.9 Conclusion

In summary, the recording of weapon trauma on bone is far from being a straightforward procedure and it is important for the historical record that it is not over-recorded since some lesions can be difficult to distinguish from post mortem breakage. Many cemeteries – particularly medieval – are found to contain at least one or two cases of healed or unhealed weapon-related trauma and it is, therefore, crucial that we familiarise ourselves with the subject.

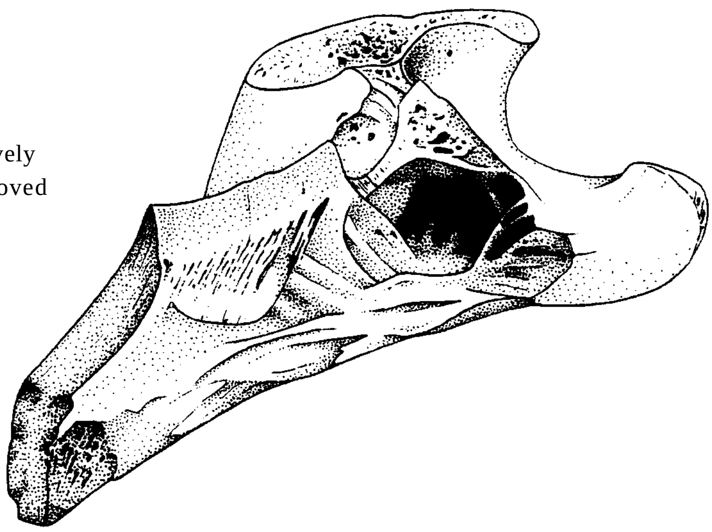


*Figure 17 Non-human bone showing breakage patterns associated with butchery. Note the concave surface on the near end. Such patterns are useful for comparison with perimortal trauma in human postcranial bones (illustration by Caroline Needham and reproduced by permission of Dr Ingrid Mainland).*

# 13 Sampling procedures for bone chemistry

*Mike Richards*

## 13.1 Introduction

Chemical analysis of bone and teeth has the potential to provide information on past human diet, health, migration and kinship, as well as the age of the skeletal material. The majority of procedures and analytical techniques that fall within the category of 'bone chemistry' are destructive, requiring sampling of bone and / or teeth. Therefore, it is important to sample skeletal material only when there are clearly defined reasons to apply such techniques. Ideally, sampling for this type of analysis should take place after other forms of analysis (eg age and sex estimation) have been undertaken. Sampling needs to be done as unobtrusively as possible, avoiding diagnostic areas.

In this section general sampling protocols for stable isotope analysis, radiocarbon dating, trace element analysis and DNA are discussed. In all of these cases researchers should check with the appropriate laboratories before sampling material, as procedures vary widely between labs. It is important to know the history of the material since excavation, especially if consolidants or preservatives have been used on the material.

## 13.2 Stable isotope analyses of bone and teeth to reconstruct past diets and life histories

Stable isotope analyses of bone and tooth collagen can provide information on past human diets (Schwarcz and Schoeninger 1991; Katzenberg and Weber 1999; Richards *et al* 1998) as well as possibly information on geographical origin and life histories (Sealy *et al* 1995; Richards *et al* 1998; Richards *et al* 2001).

### 13.2.1 Dietary reconstruction using carbon and nitrogen isotopes of bone and tooth collagen

Stable isotope analyses as used in modern and archaeological dietary studies endeavour to determine the dietary sources of carbon and nitrogen found in body tissues by measuring the ratios of the two stable carbon isotopes – $^{13}C$ and $^{12}C$ – and the ratios of the two stable nitrogen isotopes – $^{15}N$ and $^{14}N$ – in foods as well as in the body tissues of interest (DeNiro and Epstein 1978; 1981; Schwarcz and Schoeninger 1991; Ambrose 1993). The ratios of these isotopes are compared to known standards, and are presented as $\delta^{13}C$ and $\delta^{15}N$ values. Most of this research focuses on isotope measurements of the best preserved organic component of bone, the protein collagen (which comprises about 20% of modern bone by weight). Collagen carbon and nitrogen is largely derived from dietary protein (Ambrose and Norr 1993; Tiezen and Fagre 1993) and probably reflects dietary inputs from approximately the last ten years of life (Stenhouse and Baxter 1976). Carbon isotope values indicate whether dietary protein came from marine or terrestrial sources (Chisholm *et al* 1982; Schoeninger *et al* 1983), and can also distinguish between $C_3$ and $C_4$ photosynthetic-pathway plants (Vogel and van der Merwe 1977; van der Merwe 1982). In Holocene temperate Europe, human bone collagen $\delta^{13}C$ values of about -20 ‰ ± 1 ‰ indicate that dietary protein has come entirely from terrestrial $C_3$ pathway plants (the majority of plants in Europe are $C_3$), as well as from the flesh (or milk) of animals that also subsisted on only $C_3$ plants (Schoeninger *et al* 1983). A human bone collagen $\delta^{13}C$ value of about -20 ‰ ± 1 ‰ indicates that dietary protein was derived entirely from marine sources, either plants or animals (Chisholm *et al* 1982; Schoeninger *et al* 1983). $C_4$ pathway plants such as maize and millet were not consumed in Europe until relatively recently (Iron Age and later), and humans who consume them can also have $\delta^{13}C$ values close to -20 ‰ (van der Merwe 1982; Murray and Schoeninger 1988). Mammal collagen $\delta^{15}N$ values indicate the trophic level of an organism in a food web, as there is an increase in the $\delta^{15}N$ value of about 2-4 ‰ each step up the food chain (Schoeninger and DeNiro 1984). Collagen $\delta^{13}C$ and $\delta^{15}N$ values are specific to regions and ecosystems, and can vary through time, possibly related to climatic effects (van Klinken *et al* 1994; 2000; Richards and Hedges 2003). Therefore, it is important to take the ecosystem approach to isotope analyses and measure the $\delta^{13}C$ and $\delta^{15}N$ values of fauna associated temporally, as well as spatially, with the humans of interest.

Additionally, studies of $\delta^{13}C$ and $\delta^{15}N$ values from the bones and teeth of infants and juveniles can tell us about the age of weaning in past populations, as breastfeeding infants have $\delta^{15}N$ values higher than that of their mothers, which then drop to lower values when the child is weaned onto solid food (Katzenberg and Pfeiffer 1995; Herring *et al* 1998; Schurr 1998; Dupras *et al* 2001; Richards *et al* 2002).

Sampling protocols for carbon and nitrogen isotope analysis are fairly simple, as is the extraction procedure. This method requires the extraction of the protein collagen from bone, and then the further purification of this collagen for isotope analysis (Longin 1971; Brown *et al* 1988; Collins and Galley 1998). The pre-treatment of bone samples removes most of the bone mineral, so if bones have been handled without gloves there is no real danger of contamination. Stable isotope analysis often requires only a few hundred milligrams of bone, less if the bone is well preserved. Either whole bone or powdered samples are acceptable, but usually the laboratory will prefer to take samples themselves. The choice of bone to sample depends on the preservation of the material; if possible samples should be taken from the same bone element from different individuals. Often thick cortical bone (eg from femur mid-shafts) are taken, but it is also possible to undertake this analysis with bones with thinner cortices, such as ribs.

### 13.2.2 Life histories from oxygen isotopes of bone and tooth mineral

Bone mineral and dental enamel oxygen isotope values reflect the oxygen isotope values of the water that a mammal consumes (Longinelli 1984; Dupras and Schwarcz 2001; Fricke *et al* 1995; Stuart-Williams *et al* 1996; White *et al* 2000). If that mammal is migratory between climatic zones that have very different oxygen isotope ratios then the different values may be recorded in the bone or enamel. Oxygen isotopes, therefore, have the potential to identify migrating species or humans. For example, if reindeer travel great distances between distinct climatic zones in a year their antlers may record the different oxygen isotope values of the different regions. If a human child lived in one climatic zone and then moved as an adult to another, the tooth oxygen isotope values will reflect childhood location and the bone will indicate adult locality.

There are many exciting possibilities with oxygen isotope analyses of bone and enamel, but there are also serious concerns over contamination by soil and groundwater oxygen. Generally, enamel has been shown to be much more immune to contamination than bone, but this is a potential problem that needs to be addressed. There are ways to design the experiments to address the archaeological and palaeoenvironmental questions of interest, as well as indicate if diagenesis and contamination of the samples has occurred.

Sampling for oxygen isotope analysis will require consultation with the laboratory that will undertake the analyses. Usually a small sample (under 100mg) of tooth enamel or bone mineral is taken.

## 13.3 Radiocarbon dating of bone

Often the best way to date human occupation / use of a site is to obtain radiocarbon dates directly from human bone (Aitken 1990; Bowman 1990). As with stable isotope analyses this method requires pre-treatment of bone samples to extract and purify the collagen (see references above for extraction methods), since this component is often resistant to alteration or contamination.

Conventional radiocarbon dates generally require very large samples (grams), often in the order of a large section of a femur. Conventional dating of bone has largely fallen out of use now, although sometimes it is useful as these dates can be very precise, and can provide a good baseline value for a sequence if Bayesian methods are to be used to date the site (eg Hey *et al* 1999). Most dating of bone now uses accelerator mass spectrometry (AMS). This method requires much smaller samples, in the order of 500mg of bone, so is much less destructive.

As with all of these techniques, the radiocarbon dating lab should be contacted before sampling. Either whole bone or powdered samples are generally acceptable, but usually the laboratory will prefer to take the samples themselves. Most packing material will not affect the radiocarbon dates (though it is recommended that direct contact with packing foam is avoided), but the lab needs to be aware of how the material has been stored (and will ask for this on their submission forms).

The above methods require the extraction of collagen, so cremated bone is not suitable as most (if not all) of the collagen is lost during cremation. Pioneering work on radiocarbon dating cremated bone mineral has been undertaken at the radiocarbon lab in Groningen, Netherlands (Lanting *et al* 2001) and this method may soon have more widespread use.

## 13.4 Trace element analyses for reconstructing dietary and life histories

This chemical method for determining past diets has largely been discredited in recent years, due to probably insurmountable problems with diagenesis and the uptake of new elements from the soil into the bone (Burton and Price 2000; Budd *et al* 2000a). However, promising advances are being made using the isotopes of some of these elements, like lead and strontium, to determine geographical place of origin of individuals (Price *et al* 2000; 2002; Ezzo *et al* 1997; Budd *et al* 2000a and b). Currently, bone is not an appropriate material for this analysis due to contamination problems, but tooth enamel is more resistant to diagenetic changes and, in some cases, can be used for this analysis. Usually the whole tooth is used as trace element concentrations across the tooth need to be measured to test whether there has been soil contamination. As this area of research is currently in the developmental stage, sampling must be discussed with the appropriate laboratory.

## 13.5 DNA analysis

There is great potential in the analysis of ancient DNA (aDNA) extracted from human bone and teeth, but this has not yet been realised as DNA analysis of human bone has been plagued with problems related to contamination by modern human DNA (Hofreiter *et al* 2001; Cooper and Poinar 2000; Brown 2003). There are often extremely small amounts of DNA surviving in bone and just touching a bone sample can transfer millions of copies of your DNA to the ancient sample, which can swamp the original DNA signal. Contamination in laboratories is also a problem, although most modern labs have adequate procedures in place to limit this. It is worth noting that there has not been a single ancient human DNA sequence published that has not been challenged or its authenticity questioned.

Researchers have endeavoured to extract and amplify mitochondrial DNA (mtDNA) as well as sections of nuclear DNA. MtDNA is inherited maternally, so the sequence can show maternal lineage. Modern (living) human mtDNA sequences have been used to attempt to reconstruct the genetic history of Europe, focussing on whether extant peoples are descendants of Palaeolithic or Neolithic peoples, or even later migrants (Richards *et al* 2000). This area of research is problematic even on modern humans and with the problems of contamination is nearly impossible with ancient samples. Recent research (Gilbert *et al* 2003a, b) has shown that damage to the DNA can cause changes in the sequences that mimic other mtDNa sequences; for example a 'European' mtDNa sequence could be altered upon burial to resemble a 'Near Eastern' sequence.

Nuclear DNA sequences hold great promise, but are often so fragmentary that it is difficult to determine sequences of interest. Researchers are currently working on understanding the modern human genome, and we cannot hope to understand the functions of past gene sequences until we understand modern ones. Some work has been undertaken on trying to use DNA to sex individuals, looking for the presence of the Y-chromosome to indicate a male sequence (Gotherstrom *et al* 1997; Mays and Faerman 2001). Again, contamination is a very significant problem here and this method is controversial.

Another area of research that holds much promise for palaeopathology is the use of DNA analysis to try and identify and amplify pathogen DNA from bone (Zink *et al* 2002). Again, this method is in an early stage of development and almost all of the results published so far have been challenged. A major problem with this analysis is that the pathogen DNA is likely to be present in extremely small concentrations, if it has survived at all. A number of researchers have attempted to identify the pathogen that causes tuberculosis (*Mycobacterium tuberculosis*) with some success (eg Spigelman *et al* 2003; Mays and Taylor 2002; Mays *et al* 2002; Zink *et al* 2003). However, it is important to note that the presence of this pathogen does not mean that the person actually had the disease, but could simply have been a carrier.

Due to contamination problems, many aDNA researchers will not use curated human skeletal material for these analyses, but will only work on currently or recently excavated material. If DNA analysis is to be undertaken then discussions with the appropriate laboratory before excavation are necessary to determine the laboratories current most appropriate protocols. Generally, the bone will be excavated by someone from the laboratory, whose DNA sequence is known, to reduce the amount of modern human DNA that has been in contact with the skeletal material. Samples of a few hundred milligrams of dentine are usually taken, drilled from inside a tooth. If the analysis is to be undertaken on curated human remains, then samples of tooth dentine are usually taken by someone from the DNA lab, as there are precautions that need to be taken to minimise the possibility of contamination.

## 13.6 Consolidants and preservatives

A significant problem with the use of curated skeletal material for chemical analyses is the use of consolidants and preservatives, for example consolidants have a destructive effect on DNA (Millard 2001). These materials contain elements like carbon, nitrogen, and oxygen, as well as trace elements, so can contaminate the samples making chemical analyses impossible. It is possible to remove some preservatives, such as PVA (Moore *et al* 1989) for isotope analysis and radiocarbon dating, but it is much better to not to have to do this. Therefore, if researchers anticipate chemical analyses will be undertaken on samples in the future a sub-sample of untreated material should be stored for future analyses and not subjected to any kind of chemical treatment. However, the practice of applying consolidants and other chemical treatments to bones is outdated and now rarely undertaken, the problems it causes having been recognised to far outweigh the questionable 'benefits'. Applying consolidants and preservative are not recommended.

When a bone has been marked with an accession number, context number or any other form of code the affected area of bone ought not to be included in samples taken, unless the chemical composition of the ink used is accurately known.

# 14 After the bone report: the long-term fate of skeletal collections

*Simon Mays*

The main purpose of an osteological report on a skeletal assemblage from an archaeological site is to shed light on research questions pertinent to the site and the region in which it is situated. Secondary, but nevertheless important functions, are to make osteological data available to the wider scientific community and to alert other researchers to the existence of the material (Mays *et al* 2002). Although the human bone report has long been a mainstay of osteoarchaeological work, recent years have seen it occupy an increasingly prominent role in the post-excavation analysis of cemetery sites, and the results from osteological work have had an increasing influence within the discipline of archaeology as a whole. There are two principal reasons for this. Firstly, there has been increased recognition within mainstream archaeology of the value of scientific study of human remains for shedding light on questions of general archaeological interest. At the same time, osteologists are becoming increasingly cognisant of the need to orientate their skeletal reports to questions of broader interest rather than simply being content with the production of standardised lists of measurements and diseases.

Important though the osteological report is, it must be remembered that no report, however carefully prepared, can be a 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 minimal. 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. 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.

Osteoarchaeological research sheds important light on the demography, diet, health and physique of past populations (Mays 1998), and plays a major role in elucidating the history of some diseases, including osteoporosis (Mays 1999), syphilis and allied conditions (eg Mays *et al* 2003), and tuberculosis (eg Spigelman and Donohue 2003). In addition, many of the techniques used in forensic examination of human remains have been developed or tested using archaeological samples (eg Buckberry and Chamberlain 2002). 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. The long-term retention and proper curation of human skeletal remains is vital if osteoarchaeology is to continue to thrive and develop.

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. In addition, despite scientists' best efforts, it is inevitable that interpretations are coloured by cultural biases. If the evidence upon which researchers' conclusions are based is retained for study, interpretations can be refined and corrected by future workers. Only the retention of the physical evidence, in the form of skeletal material, permits osteoarchaeology to retain this ability to be self-correcting which is such a fundamental requirement of a scientific discipline. Indeed, survey of scientific publications (Buikstra and Gordon 1981) shows that re-study of skeletal collections often produces significant modification of previously accepted conclusions.

Innovations in scientific techniques allow new information to be obtained from old collections. This too ensures that museum collections are returned to time and time again. For example, when most museum collections were excavated and initially examined, many techniques now of fundamental importance to cutting-edge osteological research – such as extraction and amplification of ancient DNA or analysis of bone stable isotopes – were not available nor could their development have been foreseen. It is the unpredictable nature of scientific innovation which is one of the most powerful arguments for a consistent policy of long-term retention of collections.

It has sometimes been 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 (eg vaults) where environmental conditions are uncontrolled results in their severe deterioration (During 1997; Mays 2002). This, together with the practical and financial implications of re-excavating reinterred material means that, in practice, once remains are reburied there is permanent loss of scientific information. This denial of information to future generations is unethical.

Public opinion in the UK is generally supportive of scientific work on ancient human remains. The UK lacks activism toward wholesale reburial of human skeletons in museum collections which has been such a feature in, for example, North America. Routine reburial of UK collections would be out of kilter with public opinion. Nevertheless, despite this generally supportive atmosphere, in specific cases, public opinion – particularly local public opinion – may favour reburial of remains and clearly needs to be taken into account when making decisions on the fate of a collection. This seems most often to apply to remains excavated from churchyards still in active use (ie material excavated under Church Faculty), or to remains of some minority groups with historically distinct identities and religious practices (eg Jews).

Currently in England, human skeletal material excavated from disused burial grounds is generally retained permanently in museums or other institutions. By contrast, that excavated from churches or churchyards currently under Church of England jurisdiction is normally, as a stipulation of the granting of the Faculty, reburied, usually after some period during which scientific study can be carried out.

In response to a perceived need, both among archaeologists and among clergy, English Heritage and the Council for the Care of Churches have recently (2002) convened a Working Group whose task is to provide general guidelines for those involved in the treatment of human remains excavated from Christian contexts. The aim is to give guidance to best practice in this area and to provide a framework in order to help resolve controversial issues (including the question of retention vs reburial of remains), taking into account scientific viewpoints, secular public opinion, theological issues and legal constraints on action. One cannot, at this stage, anticipate the conclusions which might arise from this group's deliberations. Nevertheless it seems that there are two points which can be usefully be made. Firstly, it has been the writer's experience that the current practice of retention in museums of skeletal material from disused burial grounds is usually uncontroversial and, given the generally widespread public support for scientific work on excavated human remains, is probably a reasonable policy. More problematic is material excavated under Church Faculty. On the one hand, both religious and local public sensitivities may argue for its reburial (and in practice this is what normally happens). On the other, such collections are often large, well-preserved, and well-documented (eg that from Christ Church, Spitalfields) and hence of particular scientific value. It is often difficult to reconcile these different viewpoints. However, deposition of remains in unused church buildings might be one solution. 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. Failing this, efforts should be made for important collections excavated under Church Faculty, to negotiate a reasonable time-interval (at least 5–10 years) between the end of work on the skeletal report and (where it is unavoidable) reburial of the bones, so that there is ample opportunity for researchers to study the material.

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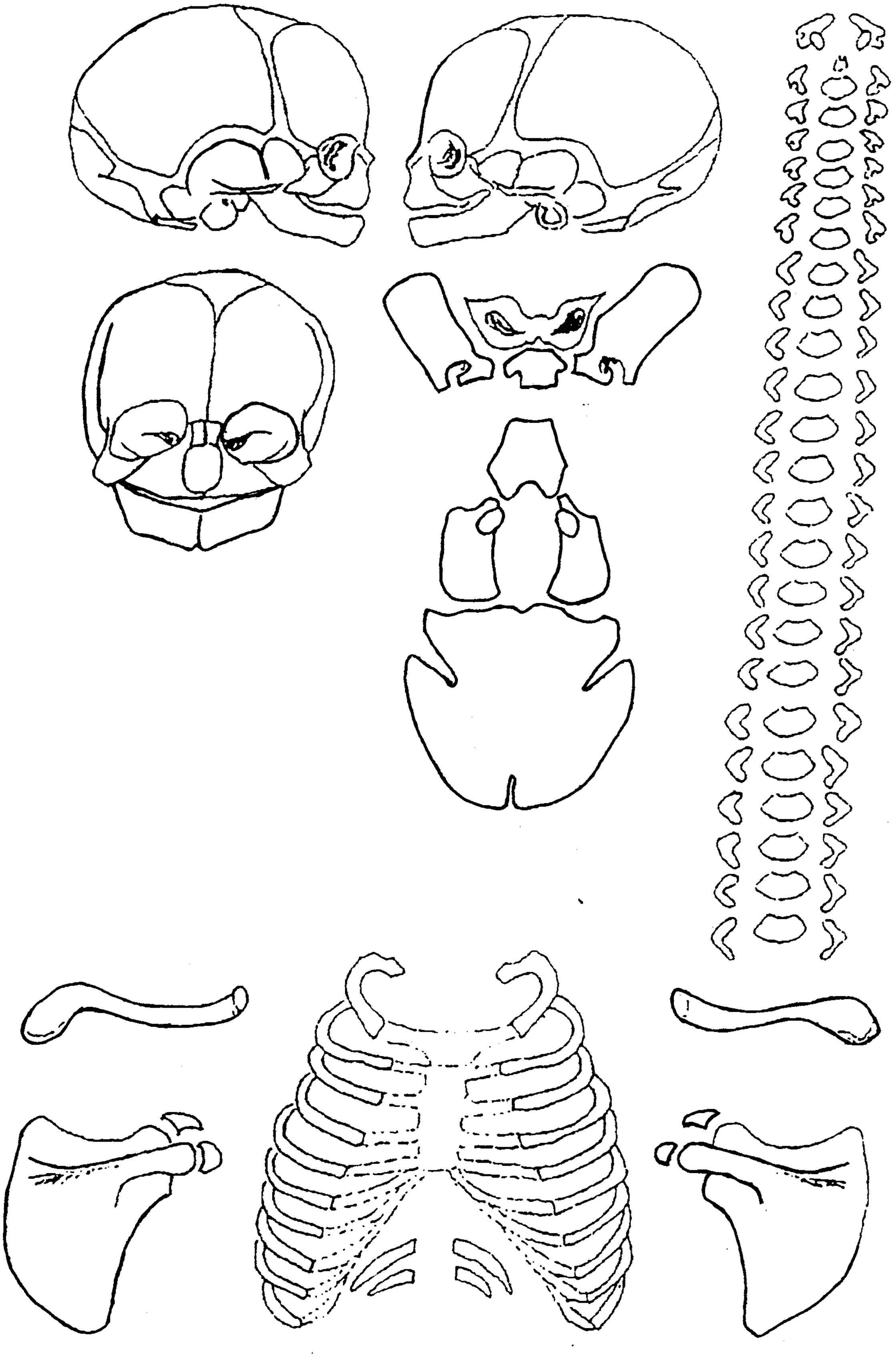
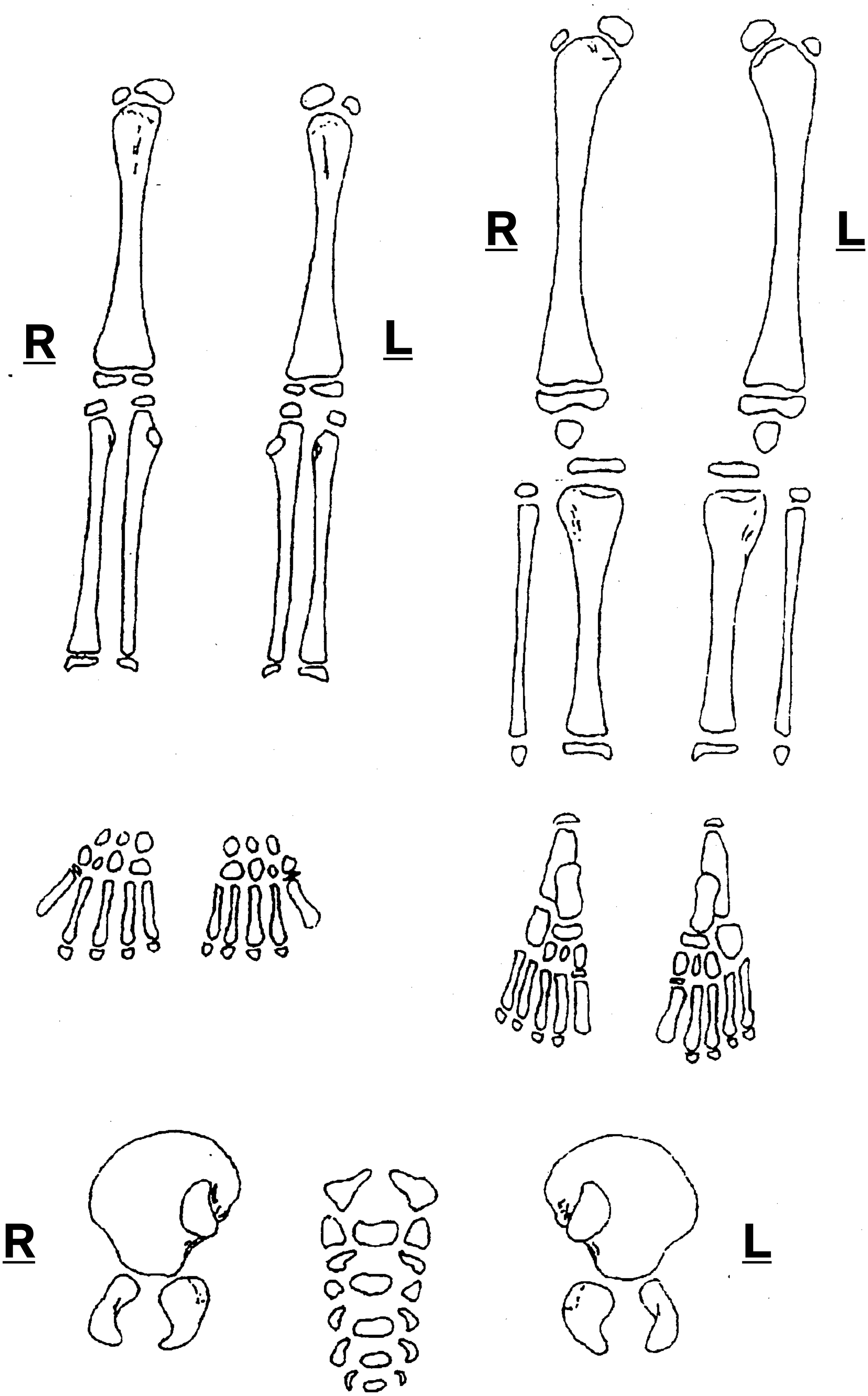
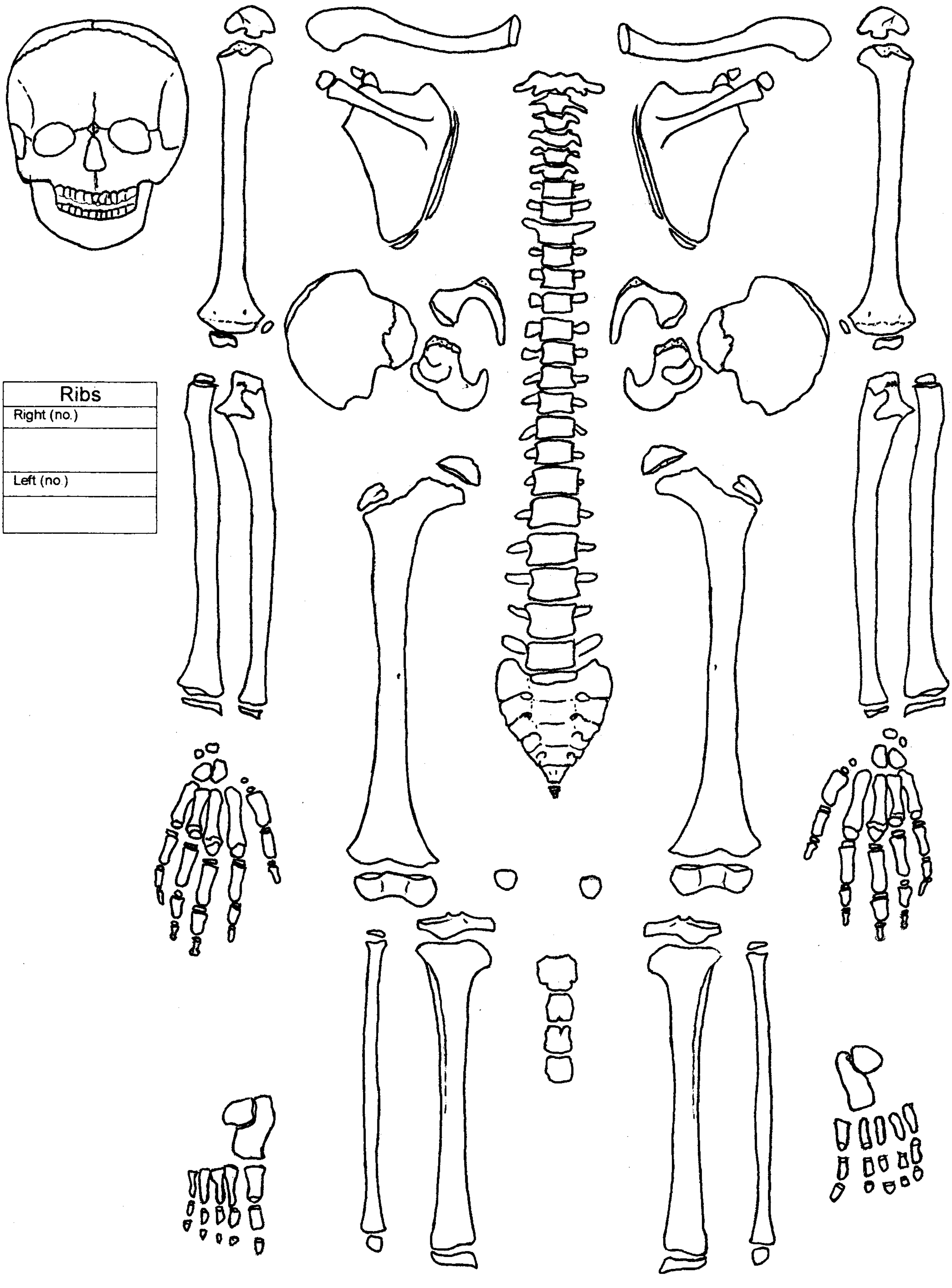
*Appendix 1* Infant skeletal record sheet (courtesy: S Black)



*Appendix 1* Infant skeletal record sheet (cont)

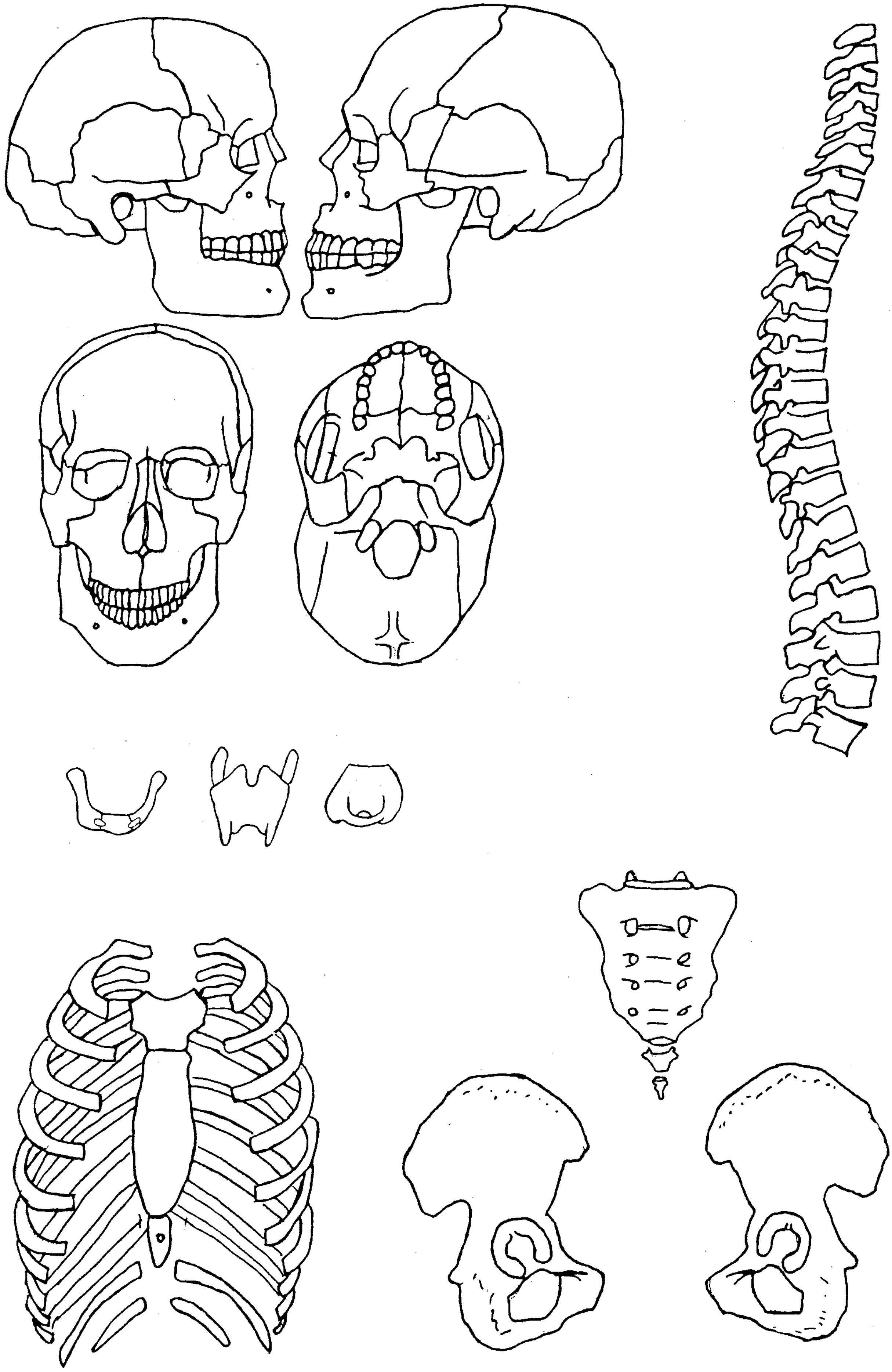


*Appendix 2* Juvenile skeletal record sheet

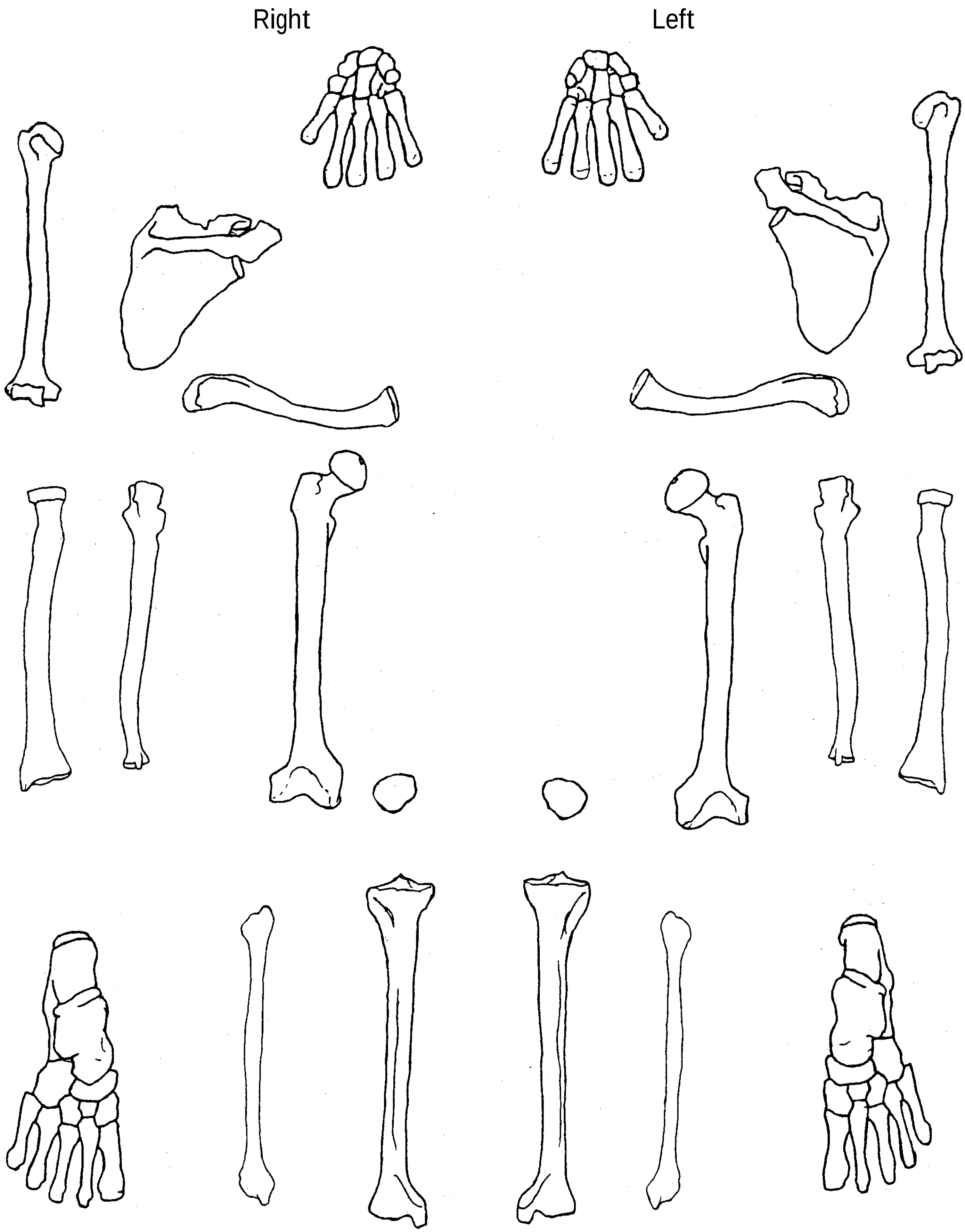


| Ribs |
|---|
| Right (no.) |
| |
| Left (no.) |
| |

*Appendix 3* Adult skeletal record sheet



*Appendix 3* Adult skeletal record sheet (cont)



*Appendix 4*

Skeleton Number _____

## Juvenile Skeletal Inventory

| Bone | Right | Left | Bone | |
|---|---|---|---|---|
| Parietal | | | Frontal | |
| Temporal | | | Occipital | |
| Maxilla | | | Pars Basillaris | |
| Nasal | | | Ethmoid | |
| Zygomatic | | | Spenoid | |
| Lacrimal | | | Fontanelle | |
| Palatine | | | Hyoid | |
| Mandible | | | Atlas | |
| Pars Lateralis | | | Axis | |

| Bone | No. Bodies | No. right arches | No. left arches |
|---|---|---|---|
| Cervical | | | |
| Thoracic | | | |
| Lumbar | | | |
| Sacrum | | | |
| Bone | Right | Left | |
| Rib | | | |
| Sternum | No. of Sternebrae = | | |
| | | | |

Right

| Bone | Prox. Epiph. | P 1/3 | M 1/3 | D 1/3 | Dist. Epiph. |
|---|---|---|---|---|---|
| Humerus | | | | | |
| Radius | | | | | |
| Ulna | | | | | |
| Femur | | | | | |
| Tibia | | | | | |
| Fibula | | | | | |

Left

| Bone | Prox. Epiph. | P 1/3 | M 1/3 | D 1/3 | Dist. Epiph. |
|---|---|---|---|---|---|
| Humerus | | | | | |
| Radius | | | | | |
| Ulna | | | | | |
| Femur | | | | | |
| Tibia | | | | | |
| Fibula | | | | | |

Right

| Bone | > 75% | 75–50 | 50–25 | <25% |
|---|---|---|---|---|
| Ilium | | | | |
| Ischium | | | | |
| Pubis | | | | |
| Scapula | | | | |
| Clavicle | | | | |
| Patella | | | | |

Left

| Bone | > 75% | 75–50 | 50–25 | <25% |
|---|---|---|---|---|
| Ilium | | | | |
| Ischium | | | | |
| Pubis | | | | |
| Scapula | | | | |
| Clavicle | | | | |
| Patella | | | | |

| Bones | Number | Bones | Number |
|---|---|---|---|
| Metacarpals | | Carpals | |
| Metatarsals | | Tarsals | |
| Hand phalanges | | Foot phalanges | |

Other unfused bone elements present

*Appendix 5*

Skeleton Number _____

## Adult Skeletal Inventory

| Bone | Right | Left | Bone | |
|---|---|---|---|---|
| Parietal | | | Frontal | |
| Temporal | | | Occipital | |
| Maxilla | | | Sphenoid | |
| Nasal | | | Vomer | |
| Zygomatic | | | Ethmoid | |
| Lacrimal | | | Hyoid | |
| Palatine | | | Cricoid | |
| Mandible | | | Thyroid | |
| Orbit | | | | |

| | | | |
|---|---|---|---|
| C1 | | T6 | |
| C2 | | T7 | |
| C3 | | T8 | |
| C4 | | T9 | |
| C5 | | T10 | |
| C6 | | T11 | |
| C7 | | T12 | |
| T1 | | L1 | |
| T2 | | L2 | |
| T3 | | L3 | |
| T4 | | L4 | |
| T5 | | L5 | |

Right ribs ☐ Left ribs ☐

Right

| Bone | Prox. J.S | P 1/3 | M1/3 | D1/3 | Dist. J.S |
|---|---|---|---|---|---|
| Humerus | | | | | |
| Radius | | | | | |
| Ulna | | | | | |
| Femur | | | | | |
| Tibia | | | | | |
| Fibula | | | | | |

Left

| Bone | Prox. J.S | P 1/3 | M1/3 | D1/3 | Dist. J.S |
|---|---|---|---|---|---|
| Humerus | | | | | |
| Radius | | | | | |
| Ulna | | | | | |
| Femur | | | | | |
| Tibia | | | | | |
| Fibula | | | | | |

Right

| Bone | >75% | 50–75 | 50–25 | <25% |
|---|---|---|---|---|
| Ilium | | | | |
| Ischium | | | | |
| Pubis | | | | |
| Scapula | | | | |
| Clavicle | | | | |
| Patella | | | | |

Left

| Bone | >75% | 50–75 | 50–25 | <25% |
|---|---|---|---|---|
| Ilium | | | | |
| Ischium | | | | |
| Pubis | | | | |
| Scapula | | | | |
| Clavicle | | | | |
| Patella | | | | |

| Bone | >75% | 50–75 | 50–25 | <25% |
|---|---|---|---|---|
| Sternum | | | | |
| Coccyx | | | | |
| Sacrum | | | | |

| Right | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Metacarpals | | | | | |
| Metatarsals | | | | | |

| Left | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Metacarpals | | | | | |
| Metatarsals | | | | | |

| | Scaphoid | Lunate | Triquetral | Pisiform | Trapezium | Trapezoid | Capitate | Hamate | Sesmoid |
|---|---|---|---|---|---|---|---|---|---|
| Right | | | | | | | | | |
| Left | | | | | | | | | |
| | Talus | Calcaneus | 1st Cun | 2nd Cun | 3rd Cun | Navicular | Cuboid | | Sesmoid |
| Right | | | | | | | | | |
| Left | | | | | | | | | |

Hand Proximal phalanges ☐ Middle phalanges ☐ Distal phalanges ☐

Foot Proximal phalanges ☐ Middle phalanges ☐ Distal phalanges ☐

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