The Role of Forensic Anthropology in Cases of Dismemberment

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Contents

Introduction

It is generally accepted that the primary role for a forensic anthropologist in the investigation of any suspicious death is to assist with the identification of the remains. This usually manifests through the provision of a biological profile that can be utilized subsequently to search missing persons' databases or be released to the public in an attempt to secure the personal identity of the deceased (Black and Ferguson, 2011; Blau and Ubelaker, 2011). However, the anthropologist's expertise, particularly in the anatomical identification of body parts and small fragments, ensures that they can also provide invaluable insights when the remains require to be identified and re-associated anatomically through physical reconstruction of the deceased (Reichs, 1998; Walsh-Haney, 1999; Iscan, 2001; Bilge et al., 2003; Cattaneo, 2007; Quatrehomme, 2007; Dirkmaat et al., 2008). The anthropologist may also have views that can assist in reaching conclusions regarding both the manner and the chronological progression of criminal dismemberment as well as proffering an expert opinion on the likely experience of the perpetrator. Indeed, many anthropologists will also be confident to provide comment on the class characteristics of tools likely utilized in the dismemberment, and a detailed discussion of this aspect will be addressed later in this text. The anthropologist will also have an opinion on how best to clean the skeletal remains for subsequent analysis, and there are a variety of options in this regard. This chapter will touch on all of the above aspects where the forensic anthropologist can provide assistance in the investigation of cases of criminal dismemberment.

Archaeologists and biological anthropologists have long recognized that tools can leave marks on the bone and have used this to hypothesize and interpret hunting, defleshing and butchery activities on faunal remains (Walker and Long, 1977; Shipman and Rose, 1983; Bromage and Boyde, 1984; Blumenschine et al., 1996; Bello and Soligo, 2008;

Bello et al., 2009; Bello, 2011; Boschin and Crezzini, 2012). Marks left on human bone have also permitted the interpretation of incidences, including interpersonal conflict, execution and ritualistic practises such as trophy hunting and even cannibalism (Villa et al., 1986; Fernandez-Jalvo et al., 1996; Soficaru et al., 2009). Being able to establish a tool type, whether stone axe, flint or other implement, is also of interest, especially when evaluating the introduction of metal weaponry into a culture (Potter, 2005; Greenfield, 2006; Bonney, 2014). These areas of research have led to some useful conclusions, but in general, the application of such broadly interpretive and largely experimental research to matters that are required to reach legal admissibility has been limited, such that conclusions are frequently contested and much debate exists.

One of the areas hotly contested is the validity of utilizing non-human remains (usually porcine but sometimes bovine or corvine) as a proxy in experimental procedures, and whilst this has obvious logistical and ethical merit, it remains an area of easy target for defence team cross-examination (Humphrey and Hutchinson, 2001; Tucker et al., 2001; de Gruchy and Rogers, 2002; Thali et al., 2003; Saville et al., 2007; Lewis, 2008; Lynn and Fairgrieve, 2009; Marciniak, 2009; Randall, 2009; Thompson and Inglis, 2009; Delabarde and Ludes, 2010; Freas, 2010; Kooi and Fairgrieve, 2010; Bailey et al., 2011; Pounder and Reeder, 2011; Parmar et al., 2012; Crowder et al., 2013; Robbins et al., 2015). Most information that is human specific therefore tends to arise from interpretation of isolated case histories, although there are a few studies that have utilized human bone (often embalmed) that has been donated for the purposes of anatomical and biological research (Bartelink et al., 2001; Pope and O'Brian, 2004; Alunni-Perret et al., 2005; Puentes and Cardoso, 2012; Capuani et al., 2014). The research on non-human material plays a vital role in exploring the relationship between cut marks and the bone, but it is essential that a realistic perspective is maintained to ensure that over-interpretation of evidence is avoided (Blumenschine et al., 1986; Morton, 2006). The research on cut marks on the bone is almost without exclusion performed on the compact region of long bones, and areas high in cancellous or diploic bone are almost exclusively ignored. This is an issue for identification as approximately 20% of the skeleton is composed of cancellous bone (Standring, 2008) for which we have virtually no scientific investigation in relation to tool marks or dismemberment.

AQ 1

The forensic anthropologist has some freedom to extrapolate evidence from confirmed causes of death to interpretive evidence for tool marks associated with dismemberment. Deaths by suicide, accident or homicide can all be translated into the dismemberment arena for interpretation of implements utilized and the marks that they leave behind. Such deaths that result from either handheld or mechanical tools can inform opinions concerning dismemberment from skeletal remains, for example, chain saws (Haynes et al., 1980; Segerberg-Konttinen, 1984; Reuhl and Bratzke, 1999; Campman et al., 2000; Koehler et al., 2004; Tournel et al., 2008; Grellner and Wilske, 2009), circular saws (Rainov and Burkert, 1994; Judd and Wyatt, 2007; Asano et al., 2008), band saws (Clark et al., 1989; Gloulou et al., 2009), wood chippers (Beers and Allen, 2007; Domenick, 2012), electrical saws (Betz and Eisenmenger, 1995; Zribi et al., 2014), guillotines (Shorrock, 2002), boat propellers (Stubblefield, 1999), general sharp injuries (Rao and Hart, 1983; Frayer and Bridgens, 1985; Ormstad et al., 1986; Rothschild et al., 2001; Ciallella et al., 2002; Bansar et al., 2003; Schmidt and Pollak, 2006; Karger et al., 2007; Schnider et al., 2009), swords (Sakaue, 2010), sickles (Sivaram et al., 1977), hatchets (Marks, 1997), screwdrivers (Croft and Ferllini, 2007) and even handheld saws (Betz and Eisenmenger, 1997). There is some

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evidence also to be obtained from non-fatal accidents, but this is limited, as of course the bone surfaces *per se* are rarely examined (Bonte, 1983; Briston and Pickett, 1991; Sullivent et al., 2006; Frank et al., 2010). AQ 3

Case Involvement

In the United Kingdom, there is no official requirement for forensic anthropological assistance in a dismemberment case, and practitioners may become involved at any stage of the investigation at the discretion and request of the police force, coroner, procurator fiscal or other forensic expert. Therefore, they may be involved at the crime scene, the deposition site, the mortuary and the laboratory. Forensic anthropologists who are certified to practise in the United Kingdom can be identified through listings by the professional body for the discipline—the Royal Anthropological Institute (https://www.therai.org.uk/forensic-anthropology).

When human remains have become scattered, the location, recording and recovery will be best achieved through the services of a forensic archaeologist working in partnership with the forensic anthropologist. It will be important to evaluate the likely carnivore activity in the area as the damage caused by scavengers can mimic traumatic injury and tool mark detection as teeth are effectively tools in this regard (Vincent, 1958; Hill, 1979; Hart, 1982; Haynes, 1982; Haglund et al., 1988, 1989; Willey and Snyder, 1989; Carson et al., 2000; Moraitis and Spiliopoulou, 2010). It is important to record and understand the range of anatomical dimensions likely for claws and teeth of scavenger species in the area, and all signs of animal activity, tracks, prints, scat, burrows/dens and so on should be recorded. Scavenging does not only occur in the wild, and, even in the indoor domestic setting, it is important to identify what are scavenging marks and what is evidence of perimortem trauma and post-mortem dismemberment (Rothschild and Schneider, 1997; Tsokos and Schulz, 1999; Steadman and Worne, 2007; Buschmann et al., 2011). Under these circumstances, the identification of the anatomical dimensions and the nature of the domestic animal should be recorded for exclusion purposes at a later date should that become necessary.

When criminal dismemberment has been identified, forensic anthropologists may become involved in the case once examination of the remains commences in the mortuary scenario. The more recent and intact the remains, then the less assistance will be required from the anthropologist, but if the deceased is decomposed or fragmented, then the additional expertise is of greater value to the investigation. Separating scavenging marks from other taphonomic change and incidental damage can be challenging (Schneider et al., 1982), and it is important that full and complete records are kept. Table 9.1 shows the procedures that the forensic anthropologist might consider following and the questions that might be posed.

On other occasions, the anthropologist may be brought into the investigation sometime after the first post-mortem examination has occurred, or the remains or sections of the remains may be sent to them for investigation in isolation from the preliminary investigations. These are challenging cases, especially as the pathologist or the mortuary technician has already removed bone sections from the deceased. Under these circumstances, each cut will have four surfaces, and even though they may have been labelled by someone else, it is vital that the anthropologist confirm the identity of the bone involved and differentiates between the post-mortem cut surface and the dismemberment surface (Figure 9.1).

Table 9.1 Procedures That the Forensic Anthropologist Might Consider Following and the Questions That Might Be Posed

1	Prior to any examination	Has the prior use of medical imaging been considered?
2	Suspected cut marks	What is the exact anatomical location of each of the marks?
		Has soft tissue been removed from the bone to visualize the cut surface(s)?
		If soft tissue has been removed, have the implements used been recorded, measured and imaged?
		Is the cut mark associated with a dismemberment/attempted dismemberment?
		If yes, is the mark a complete cut through the bone/partial cut through the bone/false start/other?
		Is the mark caused by the impact of a sharp weapon (i.e. not part of the dismemberment process)?
		What is the length and width of each of the cut marks?
		Is the mark associated with other cut marks? What is the association?
		What is the shape of the cross section of the kerf (if not cut completely through the bone)?
		What is the degree of bone 'wastage' caused by the implement?
		Has the mark been caused by a 'chopping', slicing or 'sawing' motion?
		Is it possible to ascertain the start and finish points of the cut if completely through the bone?
		Is it possible to ascertain the direction of movement of the blade and any changes in direction during the cut?
		Have all breakaway spurs been identified and described?
		Has the cutting process produced small fragments of the bone and have they all been recovered and examined?
		Have the cut surfaces of the bone been examined by magnifying glass for possible trace evidence?
		If the cut areas are to be removed, has the location of the post-mortem cuts been discussed and checked to minimize the impact on the cut areas to be examined (including false starts etc.)?
		If the cut areas are to be removed, has the location of the post-mortem cuts been marked clearly?
		Is maceration required or justified? If so, what method will be utilized?
		If maceration is to take place, what processes have been put in place to minimize damage to the cut surfaces?
3	Other possible source of marks/artefacts	What is the degree of decomposition/taphonomic change seen?
		Were the remains vulnerable to possible scavenging during the post-mortem period?
		If yes, are there any indications of scavenging on the remains?
		Were there any indications of animal activity in the area? If so, which species?
		Were the remains vulnerable to any other taphonomic influences that might cause artefacts that could resemble cut marks? For example, trampling, stony ground, burial?
		Did the recovery process involve any risk of damage to the cut areas (e.g., personnel touching the cut areas and packaging methods)?

(*Continued*)

Table 9.1 (*Continued*) Procedures That the Forensic Anthropologist Might Consider Following and the Questions That Might Be Posed

4	Human intervention after recovery	Has anyone used any sharp implements on the body as part of the post-mortem prior to the FA examination?
		If yes, identify any sharp implements used and where they came into contact with the cartilage or the bone?
		Has there been any attempt to realign and match cut ends of the bones?
5	General recording	Have all the marks been recorded on a skeletal recording form and been described within contemporaneous notes using clear indications of proximal and distal, etc.?
		Have all of the sharp implements used during the post-mortem been photographed and measured?
		If the cut areas are to be removed, has the location of the post-mortem removal cut been clearly indicated?
		Has the maceration method been recorded including photographs before, during and after the process, the method used and the time of the start and finish of the process?
6	Photography	Have all the marks been photographed with and without a scale?
		Have all the marks been photographed using a macro as well as a normal lens?
		Has photography included all possible views of the cut marks (e.g., cross sections of the kerf and macro images of striations)?
		Has an identification system (letters/numbers) been incorporated into the photographs for later identification during review of the images?

AQ 4

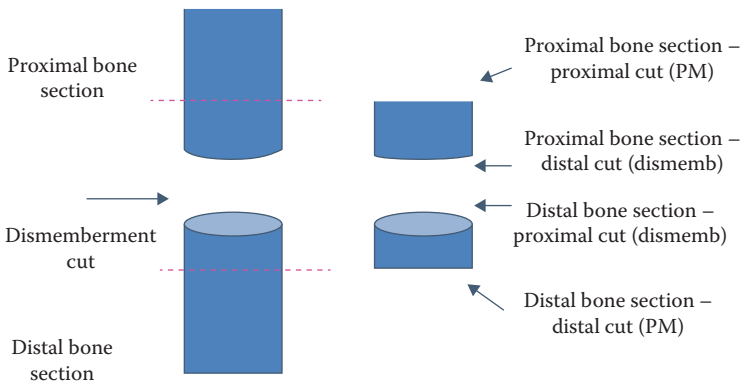

Figure 9.1 Identification of the four surfaces of a dismemberment cut following post-mortem. AQ 5

This requires a high level of experience in the siding, orientation and identification of skeletal fragments. Therefore, in a fragment associated with a dismemberment cut, the following eight features need to be determined as a minimum:

- Identify the bone (e.g., humerus and femur)
- Identify where along the length of the bone the cut may have occurred (proximal, middle, distal etc.)
- Identify the side (i.e. right or left)
- Identify the dismemberment cut surface
- Identify the mortuary post-mortem cut surface

AQ 6

- Identify which of the above two is the proximal cut and which is the distal cut
- Identify anterior and posterior borders
- Identify medial and lateral borders

In a fictitious dismemberment case such as that illustrated in Figure 9.2, there would be 22 dismemberment surfaces to be identified before further analysis could commence, but if these sections were removed at post-mortem and sent to the anthropologist in isolation, then there would be up to 44 surfaces that would require identification. The accurate anatomical identification of the dismembered segments is critical.

To ease future identification, it is important that a skeletal recording form be completed (Figure 9.2). This should include a close approximation of where the dismemberment marks occur on the relevant bone, and each of the cut surfaces should refer to an exhibit (production) reference so that reassignment is possible. Each label should also carry a 'P' or a 'D' suffix to identify whether it is the proximal or distal surface of the criminal dismemberment cut, respectively.

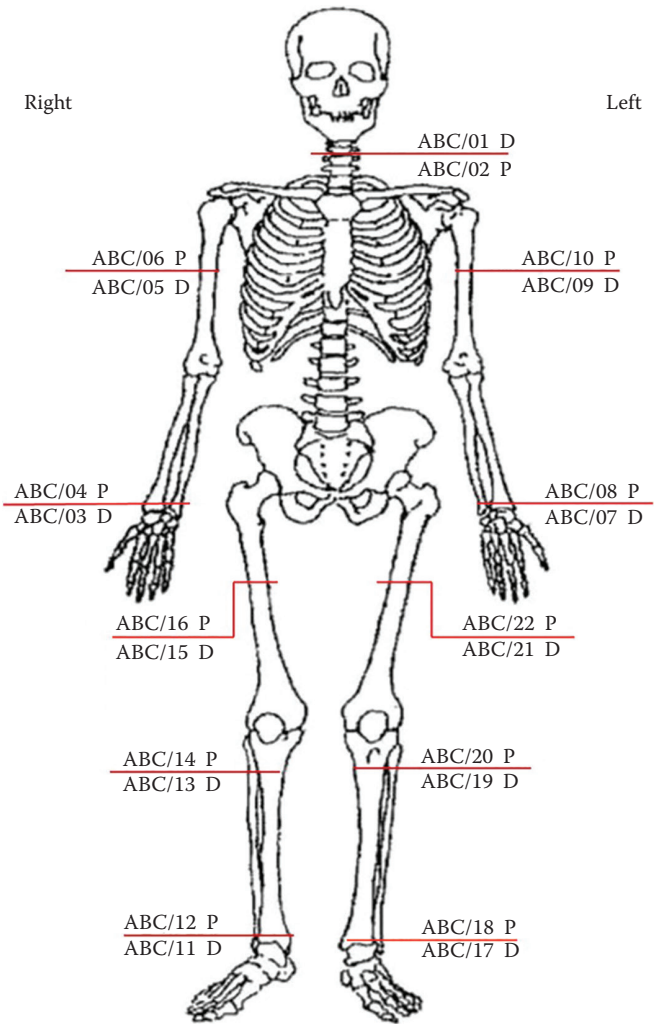

Figure 9.2 A fictitious case showing how the cut surfaces might be portrayed and identified.

The situation complicates further when the remains are not only dismembered but also fragmented. In the case described by Konopka et al. (2006), it was fortunate that the 850 fragments of the dismemberment were retained within two pots concealed in a space under the stairs, as recovery and survival of the fragments would have been considerably more challenging if, for example, they had been scattered. Equally, the 538 fragments recovered by Burghardt et al. (1996) are usual, and both cases suggest offensive rather than defensive dismemberment (see Chapter 1), but the task facing the anthropologist in terms of anatomical identification is daunting.

The most frequent sites for dismemberment occur at junctional regions with the trunk: the neck (usually in the region of the fourth to sixth cervical vertebrae), proximal humerus and proximal femur. Separation of the trunk is a messy and unpleasant experience and is often avoided, but when it does occur, the body is usually separated between the lower end of the rib cage and the upper border of the ilium of the pelvis, equating to a region between the second and fourth lumbar vertebrae, that is, in the region of the victim's waist. Limbs may be further disarticulated, and this will most likely occur within the distal segments, most commonly around the wrist for the upper limb and around either the knee or the ankle (or both) for the lower limb. It is therefore clear that the bones that will most likely bear the evidence of the dismemberment that can be analysed further are the six long bones of the limbs. Cut marks across the vertebrae, whether in the cervical or lumbar region, pass through regions high in cancellous bone where the marks left behind are extremely difficult to interpret.

Experience in identification of variation in long bone cross-sectional morphology is therefore extremely important for the accurate identification of the bone segments involved and the correct determination of anatomical borders (Figure 9.3).

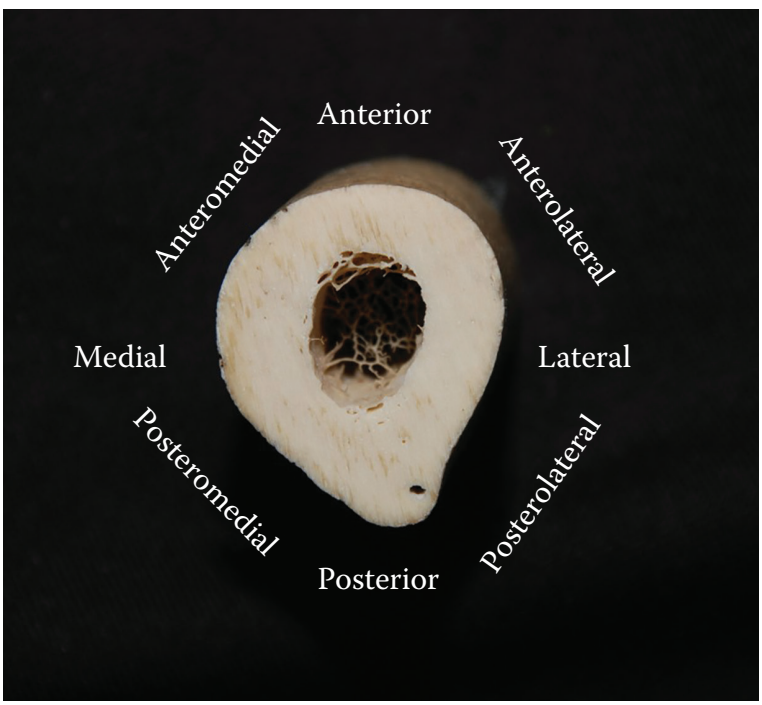

Figure 9.3 Mid-shaft section of the femur identifying the anatomical borders of a cross section.

There is no substitute for direct comparison with reference sections, and it should be remembered that the shape of the bone will vary quite extensively along the course of its length. The following photographs may be used as a quick reference guide (Figures 9.4 through 9.9), and all bones represent the right-hand side. The cross sections can be identified in isolation not just through the external shape and appearance of the bone section but

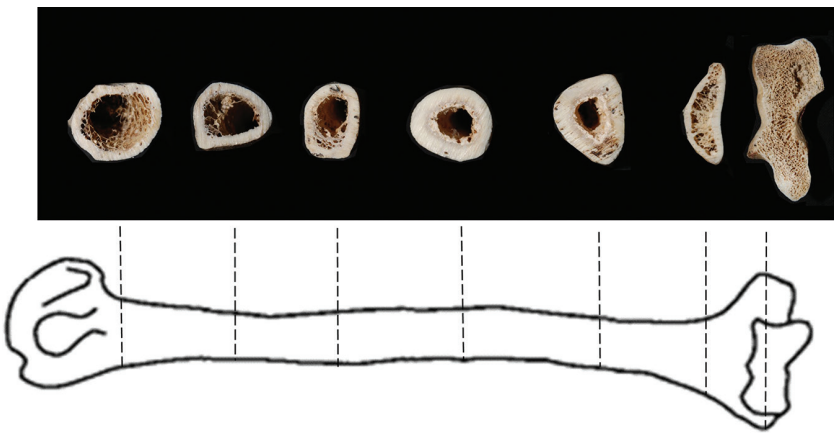

Figure 9.4 Cross-sectional morphology of the humerus.

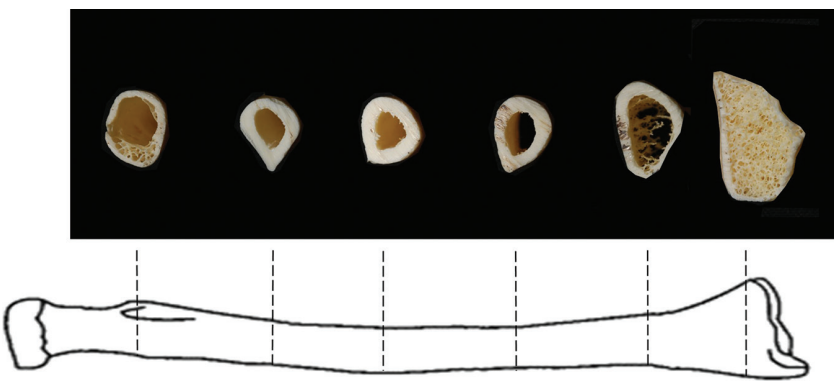

Figure 9.5 Cross-sectional morphology of the radius.

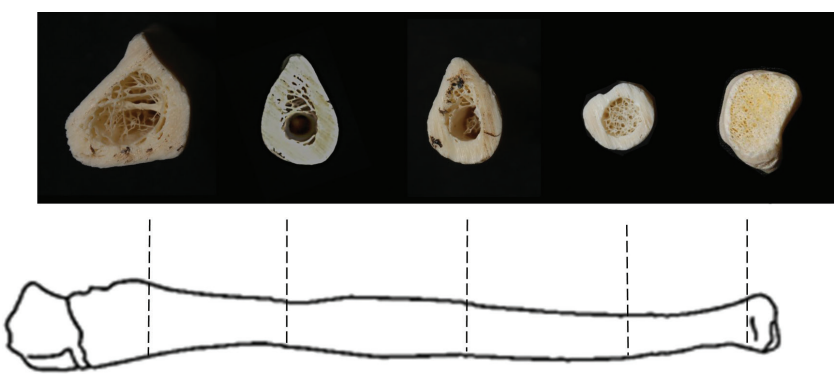

Figure 9.6 Cross-sectional morphology of the ulna.

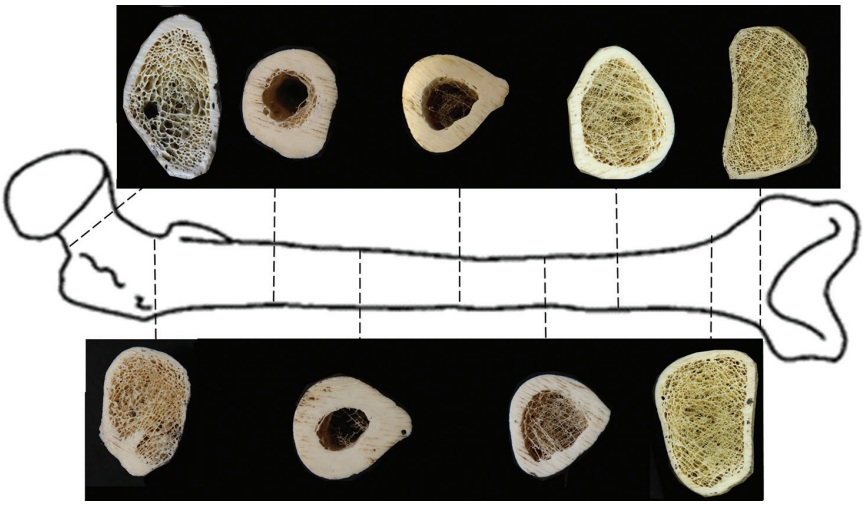

Figure 9.7 Cross-sectional morphology of the femur.

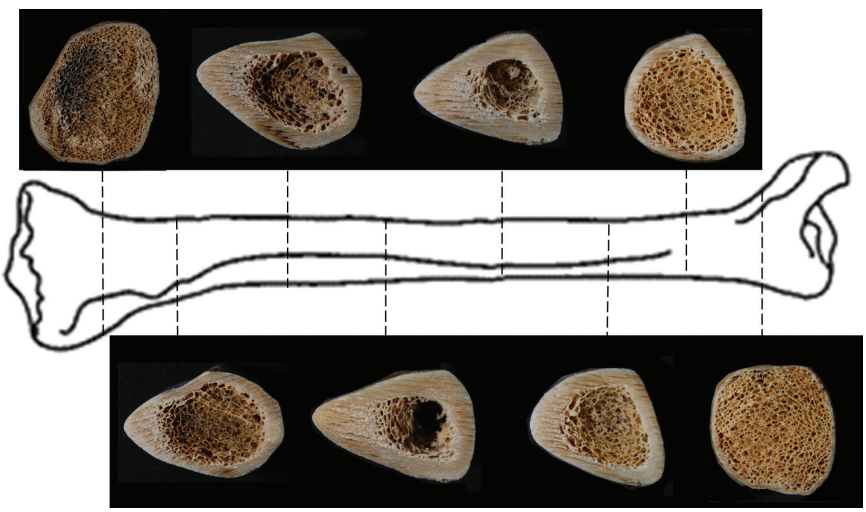

Figure 9.8 Cross-sectional morphology of the tibia.

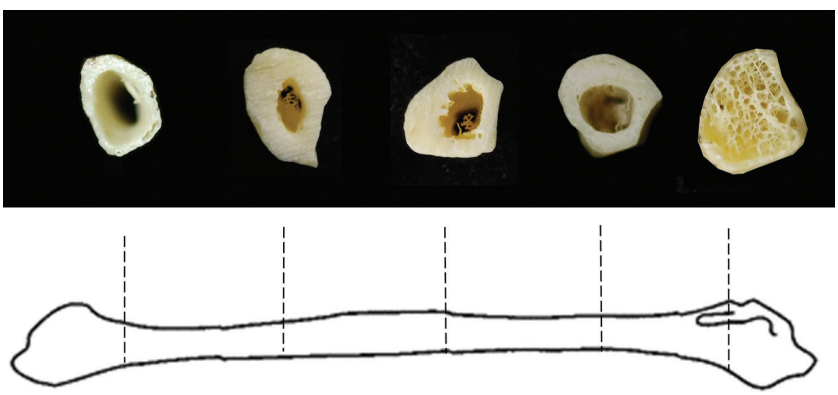

Figure 9.9 Cross-sectional morphology of the fibula.

also by assessing the volume of trabecular and cancellous bone. For example, in Figure 9.4, the first cross section from the proximal end shows a large external surface area, a thin cortical border and a large volume of cancellous compared to cortical bone. Similarly, the cross section from the middle of the bone shows a smaller external surface area, almost circular in outline with a high volume of cortical bone and the virtual absence of cancellous bone. Finally, a most distal section, such as that second from the right in Figure 9.4, shows that the external surface area is quite large, but it is flattened in the anteroposterior dimension and the volume of cancellous bone has increased compared to the relatively thin covering of compact bone.

Progression of Cuts

Being able to determine the position of the start and finish surfaces for dismemberment allows some opinion to be offered in terms of the position of the body at the time of the act. For example, determining that both humeri were sectioned from posterior to anterior indicates that the main trunk of the body was most likely prone at the time of sectioning. It may also suggest that the perpetrator had free access to both sides of the body, which may have relevance to determining the location of the dismemberment. In contrast, a body where the right humerus was sectioned from posterior to anterior but the left humerus was sectioned from anterior to posterior suggests that the body may have been turned from prone to supine or vice versa and may lend some support to a theory that the perpetrator only had access to the body from one side (e.g., in a bath that abuts with a wall along one long axis). The main separation of the sections from the trunk gives an indication of the position of the trunk during dismemberment, but once a limb has been removed, subsequent cuts are distanced from the position of the main trunk and overall body alignment. For example, a femur cut from posterior to anterior suggests that the main trunk of the body was prone at the time, but cuts made more distally within that limb may have occurred before severing from the trunk or after, and therefore care must be taken in the conclusions that can be drawn from these orientations.

Defensive dismemberment of the head at the neck most commonly occurs in the region of the fourth to sixth cervical vertebrae (Schneider et al., 1982; Denk and Stellway-Carion, 1987; Puschel and Koops, 1987; Hyma and Rao, 1991; Schmitt et al., 1995; Burghardt et al., 1996; Rajs et al., 1998; Di Nunno et al., 2006; Konopka et al., 2007; Kanetake et al., 2008; Kimmerle and Baraybar, 2008; Dogan et al., 2010; Kahana et al., 2010; Morcillo-Mendez and Campos, 2012). Within the courtroom examination, the question of whether the head was removed from the back or the front is invariably asked in reference to whether the face was turned away from the assailant. This has a psychological intent for the imagination of the jury and analysis of the damaged vertebra, and those immediately above and below it can assist in answering this question.

AQ 7

Sectioning of the long bones can occur anywhere along their shaft and inexperience on the part of the assailant can be manifest in the early attempts to separate the elements of the body. It is not uncommon for the first attempts at dismemberment to show frantic contact as the act proves to be more challenging than anticipated (Figure 9.10). The assailant may then change the dismemberment tool, and so it is important not only to look at the cut end of the bones but also to the areas of bone shaft proximal and distal to the site as they may indicate the use of additional tools and also suggest the initial site of the

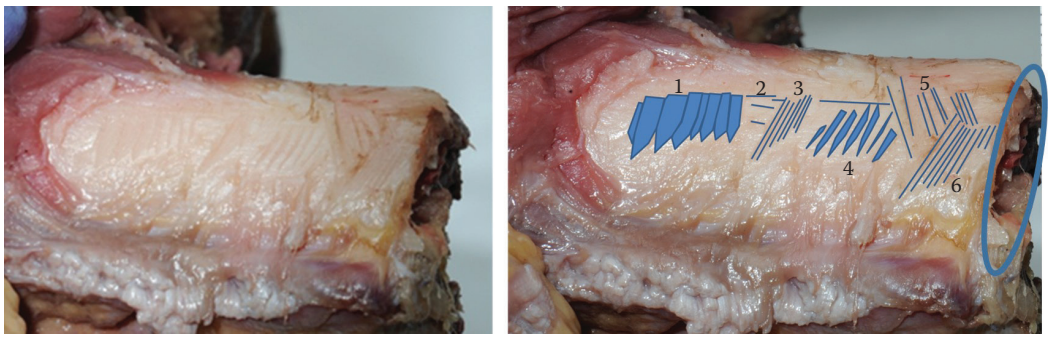

Figure 9.10 The dismemberment cut is shown to the right of the image (blue circle), but the perpetrator tried to cut the bone with a sharp blade in at least six different directions (blue lines on the shaft)—which were not successful.

dismemberment of the body. This may of course prove challenging to achieve if the bone sections have been cut at the post-mortem in the absence of the anthropologist, and access to the body is no longer viable. It is essential that these bladed attempts at cutting are not contaminated by subsequent post-mortem cuts during an attempt either to remove the soft tissue or to cut away the section of the bone. The perpetrator will learn as the dismemberment act progresses, and thus the final sites may appear 'neater' than the earlier sites of sectioning, although this cannot be held as being fact of order of cuts, as other influences such as tiredness, time and other circumstances may influence this pattern.

Prior occupations for the assailant will likely influence their approach to dismemberment. Those with medical, veterinarian, anatomical or butchery experience will be more prepared for what is required to be done and may have some skill in the planning and execution of the process. The absence of frantic cutting marks, the clean and confident wielding of a heavy bladed implement or the 'jointing' rather than cutting into segments may all suggest previous knowledge (Nachtigall, 1991; Rajs et al., 1998; Konopka et al., 2007).

The Tool

One of the first questions likely to be asked of the anthropologist, whether in the field, mortuary or laboratory, is what kind of implement may have been used in the dismemberment. The details associated with class characteristics are discussed in Chapters 7, 10 and 11, but it is possible to give early intelligence to the investigative authorities to assist them with their investigation (Houck, 1998; Symes et al., 2010). It should be possible to identify whether it is a sharp-bladed implement (such as a knife—serrated or non-serrated), a heavier blade (e.g., cleaver or machete), a handheld saw (e.g., hack saw or tenon saw), a slow reciprocating mechanical saw or a fast-blade mechanical saw (e.g., circular saw or band saw). Extreme machines including wood chippers and boat propellers are extremely rare as most perpetrators use what is directly available to them in their workspace, kitchen, garage or garden shed. We do not advocate that the inexperienced or untrained forensic anthropologists attempt identification and matching of specific blades, and this is covered in Chapters 10 and 11.

Cleaning Bones

If the remains are not completely skeletonized, then the anthropologist must consider cleaning the specimens of soft tissue to be able to analyse the cut surfaces. Care must be taken to minimize further damage to the bone surfaces, and there is some debate in the literature in relation to the most effective and least detrimental processes to be advocated.

It is often necessary to remove soft tissue from the bone to expose osseous surfaces for further analysis. Indeed, the analysis of cut marks often cannot proceed until this is undertaken because adherent tissue can obscure the detail. There are a number of methods available to facilitate this process, which is often referred to as maceration. All maceration methods have inherent strengths and weaknesses, which should be taken into account when undertaking bone cleaning for the purposes of investigating cut marks or suspected cut marks. The method utilized must maximize the exposure of bone for analysis whilst minimizing or certainly not causing further damage to the bones during the cleaning process. Damage or possible damage to the bone surface will cause an issue for analysis of the marks on the bone and for the presentation of that analysis in court.

The methods employed in maceration include heat exposure, water immersion using both hot and cold water, chemical methods that make use of various detergents and enzymes and are usually combined with water and finally natural methods that include the use of insects such as Dermestid beetles or Diptera larvae. Each of these approaches has a number of alternatives in which different chemicals or temperatures or combinations of each can be used. This section will concentrate on the impact that maceration can have on the admissibility of cut mark analysis in court and will attempt to identify those methods that do not cause damage to (or potentially cause the least damage to) the cut surfaces of the bone, because the fact that soft tissue is being removed would imply that the cut surface can or has not been fully visible without this undertaking. Degreasing of bones is rarely required in forensic situations so will not be discussed here.

AQ 8

The primary consideration when choosing a maceration method is to limit the damage that the process will potentially inflict on the surface of the bone itself. The analysis of cut marks relies on the observation of small marks and striations on the surface of the bone, and any maceration method that causes damage or breakdown to the surface of the bone itself should be avoided at all costs. What is of vital importance to remember in any cut mark analysis is that the cuts will expose the fragile cancellous bone, meaning that techniques that can be used to macerate whole bones may have a greater impact on the bones that have been cut due to the increased surface area. There are a number of methods that advocate the use of tools to strip the periosteum or hard bristled brushes to clean soft tissue from the surface of the bone, and the potential for these to introduce further damage means that these should be avoided. For the same reason, all sharp, abrasive or metallic implements should be kept away from the bone wherever possible. This includes giving special consideration to the use of scalpels and other tools by the pathologist or mortuary technician. Whilst it may not be possible to avoid the use of blades during a post-mortem, care should be taken throughout the process if cut marks are observed or suspected, and detailed records should be kept, especially if there is a possibility that the pathologist's blade has contacted the surface of the bone. It is likely in a dismemberment that a sharp blade will have been used to separate the soft tissue, and therefore the ability to exclude additional post-mortem impact is extremely important. Imaging of the

AQ 9

suspect marks (as far as possible) should be completed prior to the use of any post-mortem instrumentation—see Chapter 7. If contact is made between the post-mortem tool and the bone or cartilage surface, then this should be recorded accurately with regard to the precise location of the impact both in writing and using photography, so that any damage caused during the post-mortem can be excluded from further investigation.

Any processes that lead to further damage to the surface of the bone create a situation in which the original marks may be obscured, changed or mean that it is no longer possible to state with confidence that the marks observed are as a result of the dismemberment rather than an artefact introduced during the post-mortem or cleaning process. This therefore casts doubt on the basic premise underpinning any interpretation, which is that the marks being interpreted were caused by the act of dismemberment. If it is not possible to demonstrate this, then the evidence provided by the cut marks will carry significantly reduced weight either in court or as part of the investigation.

When a further detailed examination of the cut ends requires removal of the bone section, this must be undertaken with great care. Where possible, post-mortem separation of the bone section should be made far enough away from the dismemberment cut end so that it does not impact upon false starts or other evidence associated with the criminal act. Additionally, section removal too close to the end of the bone runs the risk of splintering and breaking bone, again obscuring and losing evidence. A full photographic record should be made prior to any cuts being made (Chapter 7). The end that is cut by the pathologist or technician during the removal of the section of the bone must be clearly marked (often by a notch, see Chapter 8) so that any analyst who subsequently examines the cut surfaces is able to differentiate, with confidence, between marks caused during the act of criminal dismemberment and that undertaken as part of the post-mortem process. Any artefacts that might be introduced during the cutting process must be recorded and marked, including any false starts or marks caused by the blade of the pathologist and so on 'skittering' during the cutting process.

Packaging of the samples should ensure that no further damage comes to the cut surfaces, either through the bone section knocking against surfaces or through the packing used to protect the surfaces (Chapter 7). Using fibrous material such as cotton wool to pack the bone is not appropriate as the fibres adhere to the cut surfaces, obscuring details or creating the potential for further damage when they are removed. Where it is unavoidable, the time that the bone spends in plastic packaging should be minimized because this encourages the growth of moulds on bone surfaces, again creating issues with visualizing the cut surfaces and causing unquantifiable damage during the cleaning process, thereby rendering any subsequent analysis open to doubt. Even if damage does not occur, it is not AQ 10
possible to demonstrate that this is the case, which can create issues when presenting any analysis in court. Preservation in formalin solution should be avoided wherever possible.

Maceration methods must ensure that damage does not occur to the cut surfaces of the bone. Table 9.2 gives an overview of methods that have been discussed in the literature, including their strengths and weaknesses. All of the methods carry some potential for damage to the bone, and one emerging theme suggests that any method used should be monitored closely throughout the investigation process, thereby allowing the practitioner greater control. In reality, there has been little research into the impact of techniques on cut marks on the bone (King and Birch, 2015), creating a situation in which there has been no quantification of the level of damage that might be experienced, especially to exposed

Table 9.2 Summary of Methods of Maceration

Methods	Positive	Negative
Mechanical methods (scraping, etc.)	Can be effective	Can damage the surface of the bone and is slow
Cold water	Effective	Slow and unpleasant
Warm water— nothing added	Effective and reasonably quick	Some damage could occur to bone surface—extent unknown
Warm water plus biological laundry detergent	Effective and reasonably quick	Damage likely to occur to bone surface—some detergents contain bleach—extent unknown
Warm water plus sodium hydroxide	Can be effective	Can damage the surface of the bone—extent unknown
Warm water plus enzymes—trypsin, pepsin and papain	Can be effective	If not fully cleaned off, will continue to work, causing likely breakdown of the bone—extent unknown
Bleach (sodium hypochlorite)	Can be effective	Extremely damaging and should be avoided at all costs
Hydrogen peroxide	Effective	Can cause damage to the surface of the bone—extent unknown
Boiling water	Effective and inexpensive	Higher temperatures cause increased damage to the bone— extent unknown
Dermestes (sp.)	Effective and reasonably quick	Will ingest the bone if not monitored
Microwave	Effective, quick and clean	Effects unknown

cancellous bone. This in turn will have an impact on the presentation of conclusions in court. Much of the literature that relates to maceration techniques in forensic situations concentrates on the requirement for speed of removal of soft tissue and the effect of any technique on DNA survival, although often at the cost of damaging the surface of the bone (Rennick et al., 2005; Steadman et al., 2006; Nawrocki, 2007; Lee et al., 2010). It is therefore vital that any practitioner is aware of all issues that might be associated with any specific method and try to minimize, or at least ensure accurate recording of, any damage caused by the process and ensure that at all stages recording is detailed and accurate.

AQ 11 Natural methods such as Dermestid beetles have been utilized for many years by museum curators and hunters to clean bone (Russell, 1947; Meeuse, 1965; Sommer and Anderson, 1974; Hefti et al., 1980; Valcarcel and Johnson, 1981; Timm, 1982; Williams and Rogers, 1989). More recently, research has been undertaken in relation to its use in the forensic arena (Offele et al., 2007; Charabidze et al., 2014); however, there is a suggestion that with extended exposure, even beetles will cause damage to the surface of the bone given enough time (Britt et al., 2008). Pits and shallow bores found on the cortical bone from material originating from the Jurassic period attribute the damage to a single insect taxon (most likely Dermestid) that had two apical teeth set on symmetrical mandibles (Britt et al., 2008). Dermestidae are a family of Coleoptera and are commonly referred to as skin beetles, larder beetles or carpet beetles (Peacock, 1993). There are more than 1000 species worldwide and *Dermestes maculatus* is the preferred for maceration purposes (Graves, 2006). Their life cycle is approximately 5–7 weeks, and most ingestion of soft tissue is undertaken at the larval stage (Figure 9.11).

Warm water maceration with either detergent or enzymes is commonly presented as being faster and more efficient than cold water maceration, which is the method that causes

Figure 9.11 *Dermestes maculatus* colony.

the least damage to the bone, although it is also the slowest (Steadman et al., 2006). Whilst it has not been investigated in relation to cut marks, even with this technique, consideration should still be paid to the potential for shrinkage and the effect that this might have on the analysis of cut marks, when bone is immersed in water and subsequently dried (Todd, 1923, 1925; Lindsten, 2002). The introduction of chemicals to speed up the process of biological breakdown, such as detergents, washing powders or sodium hydroxide (Fenton et al., 2003; Mairs et al., 2004; Uhre et al., 2015) or enzymes such as trypsin, pepsin or papain (Yin et al., 2010; Simonsen et al., 2011; Uhre et al., 2015) can speed up the maceration process; however, issues of damage to the surface of the bone have been identified and extreme care is advocated in their use (Shelton and Buckley, 1990; Mairs et al., 2004; Steadman et al., 2006; King and Birch, 2015). The chemical that has been widely used but has been shown to be most destructive is bleach (Mann and Berryman, 2012) leading to researchers such as Steadman et al. (2006) warning against its use in any forensic situation. Finally, King and Birch (2015) investigated the possibility of utilizing microwave maceration heat to remove soft tissue from the bone, finding that this delivers the ability to remove soft tissue speedily whilst causing minimum damage to the underlying bone. This is not a widely used method however, and further research is required to support these claims and ensure that parameters are established, which ensure that the bone is not overheated and damaged.

Summary

In summary, therefore, the forensic anthropologist has an important role to play in the investigation and interpretation of evidence of criminal dismemberment. Their anatomical and osteological skills can provide important information that may assist, and their involvement in early course is advocated. The analysis of cut marks has to be undertaken with care because there are a number of post-mortem artefacts, including marks left by animal scavenging and those introduced during the recovery and examination process that can cause confusion. Post-mortem processes including maceration can also cause changes that can obscure or change the cut marks and therefore should be undertaken with care by

either suitably qualified and experienced practitioners or under the guidance of the same. It is also likely that the anthropologist will be called into court to give evidence on their findings, and therefore care should be taken at every stage to ensure that the results of the analysis remain admissible.

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