Forensic Anthropology and Missing Persons Investigations

27

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27.1 Introduction

In North America, the discipline of anthropology has traditionally encompassed the sub-disciplines of archaeology, biological (or physical) anthropology, sociocultural anthropology and linguistic anthropology. Within this particular schema, forensic anthropology lies within the sub-discipline of biological (or physical) anthropology. The cross-training of anthropologists in these four sub-disciplines has meant that forensic anthropologists in North America may also be field archaeologists experienced in the search, location and recovery of human remains (Steadman, 2013).

In the United Kingdom, forensic anthropologists have originated from a variety of different backgrounds and disciplines, but have primarily derived from the fields of anatomy, biological anthropology, osteoarchaeology and skeletal biology.

Within the last decade, dedicated forensic anthropology and archaeology single and combined degrees have been offered by UK universities, and it is now the case that the vast majority of post-graduate students and early career practitioners are entering the work place with degrees in one or both of these disciplines. Given the diversity of terminology that is currently used in the literature to describe the role of the forensic anthropologist and archaeologist (which appears to depend to some extent upon the country and educational system), the term 'forensic anthropologist' will be used to describe a practitioner who is skilled in the analysis of human remains as well as having a thorough understanding of search, taphonomic change and recovery techniques (Blau & Briggs, 2011; Cattaneo, 2007).

This chapter will discuss the role of the forensic anthropologist in the search, recovery and identification of human remains as it is conducted in missing person cases. The recovery of the body and the post-recovery process will also be discussed and this chapter will include a brief consideration of the parameters of the biological profile, including the variety of new techniques currently being utilised which allow the maximum amount of information to be gained from unidentified human remains.

The involvement of the forensic anthropologist in cases of missing persons can be extensive. Individuals who go missing will often turn up unharmed after a short period of time, but in situations where this is not the case, there is a vital role for the forensic anthropologist to play. This role may variously span the initial search phase, the recovery phase and the subsequent

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anthropological analysis within the mortuary. The participation of the forensic anthropologist in one or all of these processes can ultimately assist in the identification of the missing person.

The first and most important role of the anthropologist at the scene is to identify potential bone material for recovery. The ability to recognise and identify human bone at the scene is of utmost importance. Bone can be damaged and changed by the environment, especially after exposure to heat such as fires or after decomposition and/or animal scavenging has occurred (Blau & Briggs, 2011; Haglund & Sorg, 1996; Pokines & Symes, 2013). Taphonomic factors can result in fragmentation, colour change and loss of bone matrix and structure which can make human bone difficult to locate, identify and recover. Therefore, an ability to detect and recognise both adult and juvenile human bone in these states is a vital skill for the forensic anthropologist (Blau & Briggs, 2011; Cattaneo, 2007; Haglund & Sorg, 1996, 2001). Once remains have been recovered, the role of the forensic anthropologist can continue in the mortuary, where an analysis of the remains will allow the creation of a biological profile which can assist the police in making an identification (Blau & Briggs, 2011; Cattaneo, 2007).

27.2 Search

Whilst on many occasions the involvement of the forensic anthropologist will only begin once remains are discovered, a forensic anthropologist can also advise the police in the forensic search phase of a missing persons investigation and work in tandem with other search assets such as victim recovery dogs, geophysicists, forensic archaeologists and forensic ecologists (Hunter, Simpson, & Sturdy Colls, 2013). A forensic anthropologist will generally have an in-depth knowledge of taphonomic processes that can contribute to an understanding of which search assets would be most useful to bring to any given situation (Beary & Lyman, 2012; Dirkmaat, Cabo, Ousley, & Symes, 2008). Each search situation is different, with different weather, landscapes and scenarios, so an understanding of the strengths and weaknesses of each search method and their use means that the involvement of a forensic anthropologist during the planning stages supports the establishment of a fit-for-purpose forensic search strategy that is most appropriate to the unique circumstances of each individual missing persons case (Hunter et al., 2013; Hunter & Cox, 2005).

Having the forensic anthropologist on scene during a search should be a consideration as it is not unusual for animal bones to be found in both rural and urban environments (Haglund & Sorg, 1996; Schultz, 2012). If the forensic anthropologist works within, and alongside the search team, this allows both bones and any other artefacts which might resemble bone to be identified as non-human material quickly and efficiently, enabling the search to continue with limited interruption and therefore helping to minimise both costs and the resource requirements for the search.

After decomposition, human remains may become disarticulated and scattered, especially if remains are on the surface or in a shallow burial. In this case, a careful and systematic search of the immediate and surrounding area has to be implemented to ensure that maximum recovery of the remains is achieved. Again, the forensic anthropologist has the skills to advise and support these searches, firstly by identifying bones of the skeleton that are present/missing and secondly to advise on potential scenarios such as indications of animal scavenging which may provide intelligence for the possible location of the scattered remains (Blau & Briggs, 2011; Cattaneo, 2007; Hunter et al., 2013; Moraitis & Spiliopoulou, 2010).

The presence of the forensic anthropologist at the scene is vital to a full and accurate recovery, especially where the body has undergone any degree of fragmentation, commingling, decomposition, skeletonisation or thermal damage (Blau & Briggs, 2011; Dirkmaat, 2001; Hunter et al., 2013; Moraitis & Spiliopoulou, 2010; Mundorff, 2008, 2012; Park et al., 2009; Pinheiro, 2006).

27.3 Scene Recording

When human remains are found, the length of time that the individual has been deceased will be crucial component to the overall condition of the remains (Bell, Skinner, & Jones, 1996; Duday & Guillon, 2006; Haglund & Sorg, 1996, 2001; Pinheiro, 2006). Individuals who have gone missing and died very recently prior to discovery, especially during colder weather, will tend to retain most of their soft tissue and any clothing that they were wearing may still be in situ. It should however be noted that clothing can be removed by a perpetrator or by the victim themselves during a period of confusion such as can occur with hypothermia or substance abuse (Rothschild & Schneider, 1995; Wedin, Vanggaard, & Hirvonen, 1979). A body found with clothing in situ and which still retains all of the soft tissue does not pose any issues in recovery due to the lack of fragmentation and the limited taphonomic damage caused by biotic and abiotic environmental factors encountered in cases where human remains have been found upon the ground surface. The areas that are often found to sustain taphonomic damage in the immediate post-death period are generally the hands and the head as these are the most exposed to the environment and therefore tend to be most at risk of damage by animal scavenging (Duday & Guillon, 2006; Haglund, 1996). The remainder, including the torso and the feet, may also be vulnerable if they are exposed, but clothing and footwear both tend to act to protect the body, at least initially, from animal scavenging, slowing down access. The forensic anthropologist will be able to identify the marks left by animal scavenging and in some cases can help to narrow down the species of animal involved. This information may assist with any further search which might be implemented for missing skeletal remains since the search can then identify and follow animal runs and even track back to hides (Hunter et al., 2013).

If a longer period of time has passed since the missing person has died, and especially if the weather has been warm or the body has been damaged or suffered from prolonged animal scavenging and insect activity, then there is more likely to be a greater degree of decomposition (Duday & Guillon, 2006; Haglund & Sorg, 1996; Mann, Bass, & Meadows, 1990). The subsequent loss of soft tissue can mean that the body becomes skeletonised and the bones disarticulated, and it may become spread over a large area. Fragmentation can also occur through exposure to thermal damage (Dirkmaat, 2001; Pokines & Symes, 2013).

Each scene is unique in the issues that are encountered including the degree of decomposition of the remains, the degree of damage and the amount of disturbance, disarticulation, and subsequent dispersal of the body caused by taphonomic factors such as scavenging, water flow, exposure to heat or other influences, the combination of which will vary from scene to scene (Haglund & Sorg, 1996). One of the most important factors in any successful recovery is the ability to recognise bone from other possible artefacts such as wood or other non-osseous materials (Christensen & Crowder, 2009; Klepinger, 2006). This can be especially challenging when materials have been exposed to heat (Dirkmaat, 2001; Park et al., 2009). Once bone has been discovered, the forensic anthropologist will be able to ensure that it is correctly identified as human in origin and recovered in an appropriate manner. It is important to ensure that animal and human remains are appropriately recorded and if necessary separated during recovery and that any recovery is complete and properly recorded (Dupras, Schultz, Wheeler, & Williams, 2011; Park et al., 2009). The forensic anthropologist is in the unique position to be able to undertake all of these tasks and their presence results in an efficient and timely recovery whilst also producing recording documentation to court appropriate standards.

Differentiation of fragmented or burnt bone into species of origin can be especially difficult but the importance of successful identification cannot be emphasised (Blau & Briggs, 2011; Fairgrieve, 2007; Park et al., 2009). To confuse the two can result in a number of issues; to identify animal as human bone can firstly mean an initiation of an expensive series of tests such as

DNA tests, further searches by the police and the involvement of other investigating agencies. Furthermore it may also result in family members being given incorrect information at a time when they are most vulnerable. To identify human as animal bone at best results in incomplete recovery and at worst can mean that the deceased may be missed completely whilst also causing unnecessary trauma to the family of the missing person.

Once bone has been identified as human bone, the recording and recovery methodology is important. Whilst many missing people disappear in non-suspicious circumstances, this is not true in every case and therefore accurate records in the form of documentation and photography must be maintained at each stage of the process, even if circumstances would initially suggest that the death is non-suspicious. All body recovery that is undertaken results in disruption to the scene that in turn causes changes that cannot be reversed (Hunter, 2009; Hunter et al., 2013). Accurate recording and mapping of the scene at all stages ensures that it can be recreated for the purposes of the investigation and for later presentation in court if required. All stages of the recovery of the body and associated personal effects should be recorded both through accurate documentation and through photography (Christensen & Crowder, 2009; Galloway, Birkby, Kahana, & Fulginiti, 1990; Snow, 1982). The relationship of personal effects to the body itself can also be of importance and must therefore be mapped and recorded in order to provide an understanding of the scene and of the individual and their personal effects within that scene. The forensic anthropologist will work in association with the crime scene investigators to ensure that this is carried out, creating an accurate record of events and locations.

27.4 Packaging

Once human remains have been identified, recorded and recovered they have to be appropriately packaged for successful transportation to the mortuary. Remains that have become fragile as a result of taphonomic processes or exposure to heat can be damaged further as a result of poor packaging and rough handling (Correia & Beattie, 2002; Dirkmaat, 2001; Fairgrieve, 2007). In addition, bones that still have vestiges of soft tissue adherent or which are damp are liable to continue to deteriorate if packaged in plastic and if left for an extended period of time. Mold can grow on the bone surface which not only obscures vital information such as the presence of cut marks and other trauma, but it can also cause damage to the surface of the bone and affect the chances of DNA recovery (Buzon, Eng, Lambert, & Walker, 2005; Grupe, 2007; Startari, Benoit, Quatrehomme, Carle, & Pognonec, 2013). The forensic anthropologist can therefore advise on appropriate packaging that minimises damage and maximises preservation. In relation to very fragile remains, such as those exposed to thermal damage, the stabilisation of bone may be necessary prior to packaging, although the use of chemicals such as cyanoacrylate glue should be carefully considered and only used with the agreement of other forensic scientists who may have cause to also examine the remains, such as fire investigators and forensic biologists (Griffiths & Bellamy, 1993). Photographic imaging of vulnerable areas of the bone, such as those that are used in creating a biological profile, i.e. the pubic symphysis, should also be considered prior to packaging as this will assist in ensuring that information is not lost due to the damage that might occur during transportation.

27.5 Commingled Remains

Commingled human remains may result from diverse range of incidents such as natural disasters, transportation accidents, terrorist attacks and human rights violations including war crimes, crimes against humanity and genocide (Adams & Byrd, 2008; Mundorff, 2008, 2012; Park et al., 2009). Recording and recovery protocols at the scene and the mortuary will therefore necessarily differ depending upon: the type of incident, the degree of fragmentation, disruption and commingling, the number of victims, the location and

logistics of the recovery operation, and importantly whether it is an 'open' or 'closed' population. An 'open' population is one in which the numbers of victims missing may not be known for an extended period of time or, indeed, may never be known to the investigating authorities. Whilst a 'closed' population is one in which the number and the identity of the victims are known from the outset, such as would be the case with an aircraft accident where a flight manifest would indicate the names of the individuals who had boarded the aircraft (Black & Hackman, 2009).

Commingled human remains present a particular challenge in missing persons cases and must be carefully recorded, mapped and recovered to preserve—as much as possible—the integrity of individual bodies and body parts (Tuller, Hofmeister, & Daley, 2008). In human rights investigations, the removal of commingled human remains from mass graves presents its own unique challenges. The combined effects of the decomposition of bodies buried *en masse*, the taphonomic conditions that may have influenced the decomposition (oxygen availability, soil type and pH, access by insects and carnivores, water ingress and egress, etc.) and the circumstances surrounding the original deposition or in some cases redeposition of the bodies can dramatically affect the integrity of the bodies. These can all also affect the relationship between a body and its individual body parts (Haglund, 2002; Schmitt, 2001; Skinner, 1987; Tuller et al., 2008). The excavation and recovery process must therefore be undertaken using rigorous and methodical processes in order to ensure that the human remains are carefully recorded in situ and reassociation of body parts and their relationships to one another are considered before final removal from the grave; to do otherwise may ultimately hinder the identification process in the mortuary as each individual body part would otherwise need to be separately sampled (Adams & Byrd, 2008; Prinz et al., 2007; Tuller et al., 2008).

The role of the forensic anthropologist is also integral to the identification process of commingled remains as fragmented and commingled remains need to be correctly identified to species and skeletal element. In order to maximise the potential of identification of all persons missing from the incident, if no soft or hard tissue attachment or association of commingled remains can be made at the triage station by the forensic anthropologist, each bone or body part must be broken down into individual cases and separately processed in order to maximise the potential to identify all victims from the incident (Mundorff, 2008; Mundorff, Bartelink, & Mar-Cash, 2009; Park et al., 2009).

The degree of fragmentation and commingling of human remains and the number of victims will dictate the size and number of samples that will ultimately be tested (Mundorff et al., 2009; Prinz et al., 2007). Best practice dictates that a practical threshold of minimum fragment size and/or condition for DNA analysis be established for the processing of remains. Therefore, depending on the type of incident that has generated the commingled human remains and the jurisdiction and country in which the incident has taken place, the criteria on how the commingled remains are separated and processed will necessarily be dictated by the medical examiner, the coroner or the investigating judicial authority (Mundorff, 2008).

27.6 Mortuary

If a forensic anthropologist has been involved in the recovery of the remains everything that has been recovered will have been mapped, recorded and labelled at the scene. Accurately identifying all of the remains recovered, especially if they are fragmented or damaged, is a vital role of the forensic anthropologist. Whilst a detailed knowledge of skeletal remains ensures that an accurate inventory can be made, including identification of the number of individuals that have been recovered, the separation of commingled remains and the detailed analysis of the skeletal remains must be undertaken within the mortuary.

27.7 Maceration of Remains

Whilst the forensic anthropologist has traditionally been involved in cases where loss of soft tissue is extensive because there has been either

complete loss of soft tissue or decomposition has progressed to the stage where soft tissue and organs are not discernable, the use of imaging modalities such as radiography and computed tomography (CT) has meant that anthropological analysis can be undertaken upon unidentified human remains without the necessity to undertake removal of adherent soft tissue (Thali et al., 2003). The use of imaging methods such as CT also means that even bodies that still have full soft tissue in situ can be examined and a full analysis undertaken of the underlying skeleton, allowing the forensic anthropologist to play an important role in the identification of unidentified missing persons.

Despite the use of imaging techniques, the removal of soft tissue, especially where there is only a limited amount still in situ, can still be useful. This is known as maceration and there are a number of methods available to undertake this procedure (King & Birch, 2015; Lee et al., 2010; Offele, Harbeck, Dobberstein, von Wurmb-Schwark, & Ritz-Timme, 2007; Steadman, DiAntonio, Wilson, Sheridan, & Tammariello, 2006). The forensic anthropologist will be able to advise on the most appropriate method to use, taking into account the reason for the soft tissue removal, the amount of soft tissue to be removed and the speed with which results are required. A number of maceration techniques, whilst relatively quick, can be harmful to the underlying bone rendering any subsequent analysis of cut marks or other trauma impossible because of the damage to the surface of the bone and so care must be taken with the method choice (Steadman et al., 2006).

27.8 Biological Parameters

Once the skeletal remains have been X-rayed or CT imaged and cleaned (if required), the role of the forensic anthropologist within the mortuary is to assist with the creation of a biological profile that will include an estimation of ancestry, sex, age at death, and stature, together with the identification of any individuating traits that may be present and a description of any ante- and peri-mortem trauma which may ultimately assist in the identification of the individual and the investigation into their death (Christensen, Passalacqua, & Bartelink, 2013; Klepinger, 2006; Snow, 1982). Each of these analyses can be done either directly from the skeleton or through the analysis of CT scans (Grabherr et al., 2008).

The creation of a biological profile can be used to guide the identification process, either through the publication of accurate information for press release and appeal, or to assist the investigative authorities to narrow down the possibilities in relation to any searches of possible missing persons.

Whilst DNA can ultimately assist with the identification of the individual, this depends on the ability to produce a full DNA profile from the remains, which is not always possible due to decomposition (Bender, Farfán, & Schneider, 2004). Partial DNA profiles can be of assistance however their usefulness may vary from case to case. Additionally, identification by unique identifiers such as DNA or dental records relies on finding a match between both post-mortem data and ante-mortem data (Petju, Suteerayongprasert, Thongpud, & Hassiri, 2007; Szibor, Huckenbeck, Thiel, Krause, & Lessig, 2008). Even when a DNA profile or dental chart has been created, unless the individual has been reported missing or already has their DNA on a DNA database, a DNA profile will not be available for matching and it becomes incredibly difficult to identify the dentist who holds their records, if indeed there are any dental records. The ability to appeal to the public for information can be vital for the identification process in such situations as the information gained from the public can narrow the field of inquiry.

The assessment of ancestry is purely an assessment of characteristics on the skeleton, allowing a broad brush approach to the ancestry group of an individual. This analysis does not assist with identifying the sociocultural group to which a person may belong or to which they may self-identify or have defined themselves whilst still alive (Cattaneo, 2007). For this reason, it is less useful in some situations, such as in mass disaster incidents, where the analysis of ancestry

does not contribute to information of an individual's citizenship and so is a limited method for sorting individuals. Both cranial and postcranial regions have been studied morphologically and metrically to identify the best indicators of ancestry (Hefner, 2009; Konigsberg, Algee-Hewitt, & Steadman, 2009; Wright, 1992). There is a close link between skull morphology and ancestry and as a result this is the skeletal area most commonly used in the estimation and assessment of ancestry. Both morphological and metric methods exist and there are computer programmes which have been developed to analyse ancestry groups from metric measurements of the skull (Jantz & Ousley, 1993; Wright, 1992). Testing has shown however, that these should be used with care and the results may fall far short of admissibility criteria which would be acceptable in court if the incorrect population sample is used (Elliott & Collard, 2009; Kallenberger & Pilbrow, 2012).

In relation to identification criteria, the assessment of sex and age at death are arguably the two most important of the biological parameters which the forensic anthropologist is able to identify. Research has demonstrated that it is possible to suggest the sex of an individual from a number of bones of the body, but that the most accurate analysis of sex is made from interpretation of the morphology of the pelvis and skull as these are most sexually dimorphic. Inaccurately assigning a sex to an individual set of remains can be costly in both time and money as any investigation will proceed on the information which it has been given. Biological sex separates the population into roughly two halves and any investigating team, once informed of the sex of the individual, will concentrate all their efforts on individuals of that sex, e.g. if told that the remains are female, all subsequent appeals will be for missing females and therefore the records requested and examined will also be for females. It should be noted that the analysis of biological sex is an assessment of the sex indicated by the skeletal morphology of the individual and as such is an analysis of the effects of sex hormones on the morphology of the bones and gives no indication of how an individual may have chosen to live their life (Konigsberg et al., 2009; Spradley & Jantz, 2011). There are examples of people choosing to live, dress and be known as male when they are female, or conversely be known as female when they are born male and they may choose to keep this a secret from friends and family. This scenario is not common, but it is one which does have to be considered when any analysis of sex is undertaken. Therefore, the term biological sex is used throughout this chapter to differentiate the fact that any assessment undertaken by the forensic anthropologist will be an analysis of the effect of sex hormones on the skeleton (Marshall, 1974).

This of course raises the issue of what happens in relation to juvenile remains. Prior to puberty, it is not possible to assign a biological sex to skeletal remains without the use of DNA analysis, since the morphological changes that are assessed in sex estimation occur as a result of exposure to the hormonal changes that occur at puberty (Wells, 2007). There are a number of methods which have been developed and tested for the assessment of sex from the bone tissue in juvenile remains, but none of these has the high degree of reliability which is required for any method used in a forensic case (Cunha et al., 2009; Franklin, Oxnard, O'Higgins, & Dadour, 2007). As previously stated, an error in this assessment can cause enormous issues for the investigation team, so any method which is unreliable should be avoided.

The development of an accurate age at death relies on the correct analysis of the sex of the individual. Males and females mature and age at different rates and therefore, wherever possible, age estimation has to be sex specific (Ritz-Timme et al., 2000). The forensic anthropologist can give an age at death for the individual, this will, by necessity, cover an age range since every method has to take into account individual differences caused by differences in genetics, lifestyle and socio-economic background (Ritz-Timme et al., 2000). Age is assessed by observation of changes that occur within the skeleton, in adults these changes can be observed on the bones of the pelvis, especially the pubic symphysis and the auricular surfaces and at the sternal end of the ribs. For non-adult remains the changes include

the appearance, development and fusion of ossification centres seen in juvenile skeletal development (Franklin, 2010). As these changes progress through childhood, they can be compared to reference data taken from children of known age and sex to provide an age range. These changes cease once full adult morphology is achieved and age estimation will then rely on degenerative changes in specified areas of the skeleton including the pubic symphysis, auricular surface and the sternal end of the fourth rib (Buckberry & Chamberlain, 2002; Franklin, 2010; Iscan, Loth, & Wright, 1984, 1985; Kimmerle, 2008).

The forensic anthropologist will be able to estimate the stature of the human remains if the requisite bones that are required for this analysis are present, and therefore give the investigation team a stature range which will indicate the height of the individual in life. Measuring the long bones of the limbs and inserting the measurements into sex and population specific equations allows stature estimation (Duyar, Pelin, & Zagyapan, 2006; Radoinova, Tenekedjiev, & Yordanov, 2002; Raxter, Auerbach, & Ruff, 2006). It is vital for the anthropologist to have ascertained the ancestry of the individual since the accuracy of the results is dependent on the use of the correct population specific equations. This is straightforward but can be of limited use in the identification process. It does add to the information profile that can be created and can help relatives and loved ones to recognise the description of the missing person when added to other biological parameters.

All of the methods involved in creating a biological profile are dependent upon the skeletal elements which have been recovered and how intact or damaged they have become during the post-mortem period. A complete profile may be hindered by fragmentation and damage such as can occur after a fire, however even in these cases it is unusual for an experienced forensic anthropologist not to be able to undertake an analysis, even if it might be restricted.

None of the biological profiles can themselves act as unique identifiers, however they come together to create a profile which can be used to narrow down the search for appropriate ante-mortem data which can be harvested and compared to post-mortem data to confirm the identity of an individual. In addition to age at death, sex, ancestry and stature, there are other markers on the skeleton that the forensic anthropologist will identify and which may assist in creating a biological profile, it has been suggested that some of these such as frontal sinuses may be of assistance in confirming an identification, but only if ante-mortem radiographs exist which can be compared to the post-mortem images (da Silva et al., 2009; Tatlisumak et al., 2007).

Once a biological profile has been created, the forensic anthropologist will examine the remains to check for any trauma that might be visible on the bones. Perimortem trauma, if it is present, will be of the most important for the investigation team, since this will assist with the investigation of what happened around the time of death (Galloway, Symes, Haglund, & France, 1999; Kimmerle & Baraybar, 2008; Symes et al., 2001). Any unwitnessed death that results in the recovery of a missing person has to be considered suspicious until proven otherwise and trauma analysis can support the final conclusion in relation to this. Additionally, the identification of healed trauma on the skeleton or indications of pathology can also be used to compile information to assist with any appeal that might be used to help to identify an individual (Angyal & Derczy, 1998). There are a limited number of pathologies which leave markers on bone, those that do are often long-standing disorders which result in boney changes which means that are often medical records associated with them which can be of assistance in the identification process.

Damage can be caused during the post-mortem period by factors within the environment such as plant roots or scavenging by animals such as foxes, dogs and rats (Hunter et al., 2013). All of these can leave markers on the bone and it is vital to have a trained anthropologist who is able to differentiate between this damage and peri-mortem trauma.

27.9 Conclusion

The presence of the forensic anthropologist at all stages of a missing person search, location, recovery and examination can be of use to the investigative team. Forensic anthropologists have an understanding of taphonomy and search techniques which allows them to support any team who are in the process of looking for a missing person. In the event of the discovery of an unidentified individual or individuals, the forensic anthropologist also has a role to play, both in the recovery and in the examination of the remains, providing the investigative team with information on the biological profile of the individual, even in cases of complete skeletonisation.

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References

Adams, B. J., & Byrd, J. E. (2008). *Recovery, analysis, and identification of commingled human remains*. Totowa: Springer.

Angyal, M., & Derczy, K. (1998). Personal identification on the basis of antemortem and postmortem radiographs. *Journal of Forensic Sciences, 43*, 1089–1093.

Beary, M. O., & Lyman, R. L. (2012). The use of taphonomy in forensic anthropology: Past trends and future prospects. In D. C. Dirkmaat (Ed.), *A companion to forensic anthropology*. Wiley Blackwell: West Sussex.

Bell, L. S., Skinner, M. F., & Jones, S. J. (1996). The speed of post mortem change to the human skeleton and its taphonomic significance. *Forensic Science International, 82*, 129–140.

Bender, K., Farfán, J., & Schneider, P. M. (2004). Preparation of degraded human DNA under controlled conditions. *Forensic Science International, 139*, 135–140.

Black, S., & Hackman, L. (2009). *Disaster victim identification*. Wiley Online Library.

Blau, S., & Briggs, C. A. (2011). The role of forensic anthropology in disaster victim identification (DVI). *Forensic Science International, 205*, 29–35.

Buckberry, J. L., & Chamberlain, A. T. (2002). Age estimation from the auricular surface of the ilium: A revised method. *American Journal of Physical Anthropology, 119*, 231–239.

Buzon, M. R., Eng, J. T., Lambert, P. M., & Walker, P. L. (2005). Bioarchaeological methods. *Handbook of Archaeological Methods, 2*, 871–918.

Cattaneo, C. (2007). Forensic anthropology: Developments of a classical discipline in the new millennium. *Forensic Science International, 165*, 185–193.

Christensen, A. M., & Crowder, C. M. (2009). Evidentiary standards for forensic anthropology. *Journal of Forensic Sciences, 54*, 1211–1216.

Christensen, A. M., Passalacqua, N. V., & Bartelink, E. J. (2013). *Forensic anthropology: Current methods and practice*. Oxford: Elsevier.

Correia, P. M., & Beattie, O. (2002). A critical look at methods for recovering, evaluating, and interpreting cremated human remains. In W. D. Haglund & M. H. Sorg (Eds.), *Advances in forensic taphonomy: Method, theory, and archaeological perspectives*. Boca Raton: CRC.

Cunha, E., Baccino, E., Martrille, L., Ramsthaler, F., Prieto, J., Schuliar, Y., et al. (2009). The problem of aging human remains and living individuals: A review. *Forensic Science International, 193*, 1–13.

da Silva, R. F., Prado, F. B., Caputo, I. G. C., Devito, K. L., Botelho, T. D. L., & Júnior, E. D. (2009). The forensic importance of frontal sinus radiographs. *Journal of Forensic and Legal Medicine, 16*, 18–23.

Dirkmaat, D. C. (2001). Recovery and interpretation of the fatal fire victim: The role of forensic anthropology. In W. D. Haglund & M. H. Sorg (Eds.), *Advances in forensic taphonomy: Method, theory, and archaeological perspectives*. Boca Raton: CRC.

Dirkmaat, D. C., Cabo, L. L., Ousley, S. D., & Symes, S. A. (2008). New perspectives in forensic anthropology. *American Journal of Physical Anthropology, 137*, 33–52.

Duday, H., & Guillon, M. (2006). Understanding the circumstances of decomposition when the body is skeletonized. In A. Schmitt, E. Cunha, & J. Pinheiro (Eds.), *Forensic anthropology and medicine*. Totawa: Springer.

Dupras, T. L., Schultz, J. J., Wheeler, S. M., & Williams, L. J. (2011). *Forensic recovery of human remains: Archaeological approaches*. Boca Raton: CRC.

Duyar, I., Pelin, C. A. N., & Zagyapan, R. (2006). A new method of stature estimation for forensic anthropological application. *Anthropological Science, 114*, 23–27.

Elliott, M., & Collard, M. (2009). FORDISC and the determination of ancestry from cranial measurements. *Biology Letters, 5*, 849–852.

Fairgrieve, S. I. (2007). *Forensic cremation recovery and analysis*. Boca Raton: CRC.

Franklin, D. (2010). Forensic age estimation in human skeletal remains: Current concepts and future directions. *Legal Medicine, 12*, 1–7.

Franklin, D., Oxnard, C. E., O'Higgins, P., & Dadour, I. (2007). Sexual dimorphism in the subadult mandible: Quantification using geometric morphometrics. *Journal of Forensic Sciences, 52*, 6–10.

Galloway, A., Birkby, W. H., Kahana, T., & Fulginiti, L. (1990). Physical anthropology and the law: Legal

responsibilities of forensic anthropologists. *American Journal of Physical Anthropology, 33*, 39–57.

Galloway, A., Symes, S. A., Haglund, W. D., & France, D. L. (1999). Trauma analysis. In A. Galloway (Ed.), *Broken bones. Anthropological analysis of blunt force trauma*. Springfield: Charles C Thomas.

Grabherr, S., Cooper, C., Ulrich-Bochsler, S., Uldin, T., Ross, S., Oesterhelweg, L., et al. (2008). Estimation of sex and age of "virtual skeletons" a feasibility study. *European Radiology, 19*, 419–429.

Griffiths, C. J., & Bellamy, G. D. (1993). Protection and radiography of heat affected teeth. *Forensic Science International, 60*, 57–60.

Grupe, G. (2007). Taphonomic and diagenetic processes. In W. Henke & I. Tattersall (Eds.), *Handbook of paleoanthropology*. Berlin: Springer.

Haglund, W. (1996). Dogs and coyotes: Postmortem involvement with human remains. In W. D. Haglund & M. H. Sorg (Eds.), *Forensic taphonomy: The postmortem fate of human remains*. Boca Raton: CRC.

Haglund, W. D. (2002). *Recent mass graves, an introduction*. Boca Raton: CRC.

Haglund, W. D., & Sorg, M. H. (1996). *Forensic taphonomy: The postmortem fate of human remains*. Boca Raton: CRC.

Haglund, W. D., & Sorg, M. H. (2001). *Advances in forensic taphonomy: Method, theory, and archaeological perspectives*. Boca Raton: CRC.

Hefner, J. T. (2009). Cranial nonmetric variation and estimating ancestry. *Journal of Forensic Sciences, 54*, 985–995.

Hunter, J. (2009). Domestic homicide investigations in the United Kingdom. In S. Blau & D. H. Ubelaker (Eds.), *Handbook of forensic anthropology and archaeology*. Walnut Creek: Left Coast Press.

Hunter, J., & Cox, M. (2005). *Forensic archaeology: Advances in theory and practice*. Oxon: Routledge.

Hunter, J., Simpson, B., & Sturdy Colls, C. (2013). *Forensic approaches to buried remains*. Hoboken: Wiley.

Iscan, M. Y., Loth, S. R., & Wright, R. K. (1984). Age estimation from the rib by phase analysis: White males. *Journal of Forensic Sciences, 29*, 1094–1104.

Iscan, M. Y., Loth, S. R., & Wright, R. K. (1985). Age estimation from the rib by phase analysis: White females. *Journal of Forensic Sciences, 30*, 853–863.

Jantz, R. L., & Ousley, S. D. (1993). *FORDISC 1.0: Computerized forensic discriminant functions*. Knoxville: University of Tennessee.

Kallenberger, L., & Pilbrow, V. (2012). Using CRANID to test the population affinity of known crania. *Journal of Anatomy, 221*, 459–464.

Kimmerle, E. H. (2008). Analysis of age-at-death estimation through the use of pubic symphyseal data. *Journal of Forensic Sciences, 53*, 558–568.

Kimmerle, E. H., & Baraybar, J. P. (Eds.). (2008). *Skeletal trauma*. Baton Rouge: CRC.

King, C., & Birch, W. (2015). Assessment of maceration techniques used to remove soft tissue from bone in Cut mark analysis. *Journal of Forensic Sciences, 60*, 124–135.

Klepinger, L. L. (2006). *Fundamentals of forensic anthropology*. Totawa: Wiley.

Konigsberg, L. W., Algee-Hewitt, B. F., & Steadman, D. W. (2009). Estimation and evidence in forensic anthropology: Sex and race. *American Journal of Physical Anthropology, 139*, 77–90.

Lee, E. J., Luedtke, J. G., Allison, J. L., Arber, C. E., Merriwether, D. A., & Steadman, D. W. (2010). The effects of different maceration techniques on nuclear DNA amplification using human bone. *Journal of Forensic Sciences, 55*, 1032–1038.

Mann, R. W., Bass, W. M., & Meadows, L. (1990). Time since death and decomposition of the human body: Variables and observations in case and experimental field studies. *Journal of Forensic Sciences, 35*, 103–111.

Marshall, W. A. (1974). Interrelationships of skeletal maturation, sexual development and somatic growth in man. *Annals of Human Biology, 1*, 29–40.

Moraitis, K., & Spiliopoulou, C. (2010). Forensic implications of carnivore scavenging on human remains recovered from outdoor locations in Greece. *Journal of Forensic and Legal Medicine, 17*, 298–303.

Mundorff, A. Z. (2008). *Anthropologist-directed triage: Three distinct mass fatality events involving fragmentation of human remains. Recovery, analysis, and identification of commingled human remains*. Totowa: Springer.

Mundorff, A. Z. (2012). Integrating forensic anthropology into disaster victim identification. *Forensic Science, Medicine, and Pathology, 8*, 131–139.

Mundorff, A. Z., Bartelink, E. J., & Mar-Cash, E. (2009). DNA preservation in skeletal elements from the World Trade Center disaster: Recommendations for mass fatality management. *Journal of Forensic Sciences, 54*, 739–745.

Offele, D., Harbeck, M., Dobberstein, R. C., von Wurmb-Schwark, N., & Ritz-Timme, S. (2007). Soft tissue removal by maceration and feeding of Dermestes sp.: Impact on morphological and biomolecular analyses of dental tissues in forensic medicine. *International Journal of Legal Medicine, 121*, 341–348.

Park, D. K., Park, K. H., Ko, J. S., Kim, Y. S., Chung, N. E., Ahn, Y. W., et al. (2009). The role of forensic anthropology in the examination of the daegu subway disaster (2003, Korea). *Journal of Forensic Sciences, 54*, 513–518.

Petju, M., Suteerayongprasert, A., Thongpud, R., & Hassiri, K. (2007). Importance of dental records for victim identification following the Indian Ocean tsunami disaster in Thailand. *Public Health, 121*, 251–257.

Pinheiro, J. (2006). Decay process of a cadaver. In A. Schmitt, E. Cunha, & J. Pinheiro (Eds.), *Forensic anthropology and medicine: Complementary sciences from recovery to cause of death*. Totawa: Springer.

Pokines, J., & Symes, S. A. (2013). *Manual of forensic taphonomy*. Boca Raton: CRC.

Prinz, M., Carracedo, A., Mayr, W., Morling, N., Parsons, T., Sajantila, A., et al. (2007). DNA Commission of the International Society for Forensic Genetics (ISFG): Recommendations regarding the role of forensic genetics for disaster victim identification (DVI). *Forensic Science International. Genetics, 1*, 3–12.

Radoinova, D., Tenekedjiev, K., & Yordanov, Y. (2002). Stature estimation from long bone lengths in Bulgarians. *Journal of Comparative Human Biology, 52*, 221–232.

Raxter, M. H., Auerbach, B. M., & Ruff, C. B. (2006). Revision of the fully technique for estimating statures. *American Journal of Physical Anthropology, 130*, 374–384.

Ritz-Timme, S., Cattaneo, C., Collins, M., Waite, E., Schütz, H., Kaatsch, H.-J., et al. (2000). Age estimation: The state of the art in relation to the specific demands of forensic practise. *International Journal of Legal Medicine, 113*, 129–136.

Rothschild, M., & Schneider, V. (1995). "Terminal burrowing behaviour"—A phenomenon of lethal hypothermia. *International Journal of Legal Medicine, 107*, 250–256.

Schmitt, S. (2001). Mass graves and the collection of forensic evidence: Genocide, war crimes, and crimes against humanity. In W. D. Haglund & M. H. Sorg (Eds.), *Advances in forensic taphonomy: Method, theory, and archaeological perspectives*. Boca Raton: CRC.

Schultz, J. J. (2012). Determining the forensic significance of skeletal remains. In D. C. Dirkmaat (Ed.), *A companion to forensic anthropology*. Wiley Blackwell: West Sussex.

Skinner, M. (1987). Planning the archaeological recovery of evidence from recent mass graves. *Forensic Science International, 34*, 267–287.

Snow, C. C. (1982). Forensic anthropology. *Annual Review of Anthropology, 11*(1), 97–131.

Spradley, M. K., & Jantz, R. L. (2011). Sex estimation in forensic anthropology: Skull versus postcranial elements. *Journal of Forensic Sciences, 56*, 289–296.

Startari, L., Benoit, J.-N., Quatrehomme, G., Carle, G., & Pognonec, P. (2013). Comparison of extractable DNA from bone following six-month exposure to outdoor conditions, garden loam, mold contamination or room storage. *Medicine, Science, and the Law, 53*, 29–32.

Steadman, D. W. (2013). The places we will go: Paths forward in forensic anthropology. In D. H. Ubelaker (Ed.), *Forensic science: Current issues, future directions*. Wiley Blackwell: West Sussex.

Steadman, D. W., DiAntonio, L. L., Wilson, J. J., Sheridan, K. E., & Tammariello, S. P. (2006). The effects of chemical and heat maceration techniques on the recovery of nuclear and mitochondrial DNA from bone. *Journal of Forensic Sciences, 51*, 11–17.

Symes, S. A., Williams, J. A., Murray, E. A., Hoffman, J. M., Holland, T. D., Saul, J. M., et al. (2001). Taphonomic context of sharp-force trauma in suspected cases of human mutilation and dismemberment. In W. D. Haglund & M. H. Sorg (Eds.), *Advances in forensic taphonomy: Method, theory, and archaeological perspectives*. Boca Raton: CRC.

Szibor, R., Huckenbeck, W., Thiel, W., Krause, D., & Lessig, R. (2008). Thoughts for the organisation of an early phase response to preserve victim identification information after mass disasters: A contribution to: ISFG: Recommendations regarding the role of forensic genetics for disaster victim identification (DVI by M. Prinz, A. Carracedo, WR Mayr, N. Morling, TJ Parsons, A. Sajantila, R. Scheithauer, H. Schmitter, PM Schneider). *Forensic Science International, 177*, e39–e42.

Tatlisumak, E., Yilmaz Ovali, G., Aslan, A., Asirdizer, M., Zeyfeoglu, Y., & Tarhan, S. (2007). Identification of unknown bodies by using CT images of frontal sinus. *Forensic Science International, 166*, 42–48.

Thali, M. J., Yen, K., Schweitzer, W., Vock, P., Boesch, C., Ozdoba, C., et al. (2003). Virtopsy, a new imaging horizon in forensic pathology: Virtual autopsy by postmortem multislice computed tomography (MSCT) and magnetic resonance imaging (MRI)—A feasibility study. *Journal of Forensic Sciences, 48*, 386–403.

Tuller, H., Hofmeister, U., & Daley, S. (2008). Spatial analysis of mass grave mapping data to assist in the reassociation of disarticulated and commingled human remains. In B. J. Adams & J. E. Byrd (Eds.), *Recovery, analysis, and identification of commingled human remains*. Totowa: Springer.

Wedin, B., Vanggaard, L., & Hirvonen, J. (1979). "Paradoxical undressing" in fatal hypothermia. *Journal of Forensic Sciences, 24*, 543–553.

Wells, J. C. (2007). Sexual dimorphism of body composition. *Best Practice and Research Clinical Endocrinology and Metabolism, 21*, 415–430.

Wright, R. V. (1992). Correlation between cranial form and geography in homo sapiens: CRANID—A computer program for forensic and other applications. *Archaeology in Oceania, 27*, 128–134.