

Redefining forensic anthropology in the 21st century and its role in mass fatality investigations

Nicholas Márquez-Grant¹, Julie Roberts²

¹*Cranfield Forensic Institute, Cranfield University, Bedford, UK*

²*School of Biological and Environmental Sciences, Faculty of Science, Liverpool John Moores University, Liverpool, UK*

SUMMARY

Forensic anthropology is a dynamic field, with its definition having to reshape itself and expand continuously. The challenges faced as well as its potential have grown in synergy with other areas in forensic science. In academia, as well as in practice, the discipline has seen much specialisation in different areas. In particular in recent years, the importance of the forensic anthropologist has led to an increase volume of casework for these scientists, and an important role in disaster victim identification worldwide. This paper sees the need for a revised definition which reflects the nature of the work, both with the living as well as with the dead, in individual domestic cases or international human rights' investigations. A review of the work undertaken by forensic anthropologists is provided with special emphasis on mass fatality incidents. This paper also explores the discipline's contribution to DNA analysis and positive identification. It is important to highlight the forensic anthropologists' role and their potential in any deployment of a National or International Disaster Victim Identification team.

Key words: Forensic Anthropology – Mass disasters – Disaster Victim Identification – Human remains – Fire scenes – DNA

INTRODUCTION

Definitions of forensic anthropology have reflected the evolution of the discipline over the past 20 years. A commonly accepted definition is currently “the application of the science of physical or biological anthropology to the legal process” (e.g., see ABFA, 2018), although this has now expanded to include human rights cases, as part of what some have called ‘Humanitarian Forensic Action’ or ‘Forensic Humanitarianism’ (Guyomarc’h and Congram, 2015; Cordner and Tidball-Binz, 2017; Moon, 2013; Parra et al., 2020). More recently, historical cases involving the recovery, identification and repatriation of casualties from the First and Second World Wars and subsequent conflicts have also been categorised as forensic anthropology (Loe et al., 2014; Cox et al., 2016; Emanovsky and Belcher, 2012). The expansion of the definition in these contexts recognises the need for the

Corresponding author:

Dr Nicholas Márquez-Grant. Cranfield Forensic Institute, Cranfield University, Defence Academy of the United Kingdom, Shrivenham, SN6 8LA, UK.
E-mail: n.marquezgrant@cranfield.ac.uk

anthropologist to conform to the standards required by forensic genetic laboratories. He or she is required to work closely with DNA scientists and be cognisant of forensic protocols relating to chain of custody, integrity of evidence and how to minimise the risks of cross contamination and misidentifications.

The original remit of the forensic anthropologist was to help with the identification of the deceased and he or she was based in the laboratory or mortuary. The role has now expanded to crime scene attendance, starting with understanding the context of human remains and assisting with recovery (Dirkmaat et al., 2008; Blau, 2018). Today, forensic anthropology has evolved into different specialities and stronger ties have developed with forensic pathology, odontology, radiology, genetics and crime scene investigation. In many countries, the interrelation with archaeology is also particularly strong (Blau and Ubelaker, 2016; Hunter et al., 2013; Groen et al., 2015). From an initial focus on skeletonised remains it has now been recognised that the skills of the forensic anthropologist can also be applied to the examination of fresh, decomposed, mummified and burnt bodies from a variety of contexts. Previously working as assistants to forensic pathologists primarily, forensic anthropologists now often take the lead in certain types of humanitarian and mass fatality scenarios, collaborating with and advising the pathologist, although it must be emphasised that it is still not the role of the forensic anthropologist to determine cause of death in a forensic setting. In addition, some management of the unidentified decedents and other roles have been undertaken by forensic anthropologists within a Medical Examiner or Coroner's office (Crowder et al., 2016).

Although much of the work of the forensic (physical) anthropologist deals with the dead, not all definitions of forensic anthropology have encompassed the fact that some also study the living. This skill-set is sometimes "country specific", depending on the educational background of the forensic anthropologist and the organisation they work from which varies between nations (e.g., see Kranioti and Paine, 2011; Obertová et al., 2019; Christensen et al.,

2015). Thus, the forensic anthropologist can assist with gait analysis, age estimation in the living or identification of a suspect (Black et al., 2010; Beh and Payne-James, 2010; Cattaneo, 2007; Schmeling et al., 2008; Black et al., 2010). In some cases, there has been also an awareness of the value of forensic anthropologists with assisting in the identification of living individuals left unconscious from a mass disaster (Quatrehomme et al., 2019; De Boer et al., 2019).

Further specialisation in the field has been increasing too, as methods become more niche, and what was an examination of human remains by one anthropologist may now require several, with different areas of expertise, on a single case. Finally, in previous and current definitions of forensic anthropology it is important to consider whether the term should be limited to just those examining the body, as anthropology in its broadest sense also encompasses social and cultural anthropology. There has been some mention of including these branches of anthropology in the definition of forensic anthropology, or conversely, defining the discipline as we currently understand it more narrowly as 'forensic physical anthropology' (Maples, 1980; Lovis, 1992). It is known that a number of social and cultural anthropologists have worked in forensic or judicial cases (e.g., Rosen, 1977; Turner, 1992; Burke, 2011; Trigger et al., 2013; Holden, 2019). These experts may provide opinion regarding cultural practices around the dead, provide information on cultural and bio-cultural indicators or modifications on a body. They may also work closely with families in mass fatality incidents or human rights cases. In these instances, it is true that some of the anthropologists who undertake the examination of remains have also been trained in social and cultural anthropology, so in this context it could indeed be classified as 'forensic anthropology'.

The history and current status of forensic anthropology and the methods used within the discipline have been covered extensively in the literature (e.g., Klepinger, 2006; Komar and Buikstra, 2008; İşcan and Steyn, 2013; Tersigni-Tarrant and Langley, 2017; Blau, 2018; Ubelaker, 2018; Ubelaker et al., 2019a). A number of specialised books have been written on trauma,

ethics, dismemberment, and burnt remains (e.g. Schmidt and Symes, 2015; Ross and Cunha, 2019; Thompson, 2001; Walsh-Haney and Lieberman, 2005; France, 2012; Blau, 2016a; 2016b; Passalacqua and Pilloud, 2018; Márquez-Grant et al., 2019), bias (Nakhaeizadeh et al., 2014; Passalacqua and Pilloud, 2018), and specific methods for estimating age, sex, etc., as well as reviews on research trends worldwide (Lei et al., 2019). The importance of forensic anthropology as well as archaeology has increased primarily since the Human Rights Investigations of mass graves in Latin America in the 1980s and subsequently the Balkans in the 1990s. Although initially much work concentrated in the identification of the deceased in the laboratory or mortuary, as Dirkmaat et al. (2008) indicated, this has recently expanded to attending the crime scene to understand the context in which the remains were found, and encompassing the field of forensic taphonomy. Moreover, this now extends to participating not only in the recovery of human remains in the field but also actively participating in the search for missing persons (Márquez-Grant, 2018). The forensic anthropologists works closely alongside the forensic archaeologist or they may use their own skills depending on their background and training (e.g., Hunter and Cox, 2005; Ferllini, 2007; Dupras et al., 2012; Hunter et al., 2013; Groen et al., 2015; Barone and Groen, 2018). With this in mind, we consider that a revised definition which encompasses the contribution forensic anthropologists provide in the search, recovery (whether applying archaeological knowledge or working alongside a forensic archaeologist), identification and management of the deceased, the interpretation of circumstances surrounding death in medico-legal and humanitarian contexts, and the identification of the living, could be proposed. Of course, social and cultural anthropology may well be used in casework and this may also be part of the physical anthropologist's training. Likewise, in some countries forensic anthropologists may already work as forensic pathologists. The suggested definition below, therefore, reflects how the role of the forensic physical anthropologist, who may work alongside others experts in the field of forensic medicine, forensic odontology,

social and cultural anthropology, etc., has evolved in recent times:

“Forensic Physical Anthropology can be defined as the analysis of the human body to assist with the identification of the living and the dead, the recovery and repatriation of the deceased, and the interpretation of circumstances surrounding death in medico-legal and humanitarian contexts”.

In addition to domestic casework, human rights missions and other operations, and increasing specialisations in the fields of imaging, histology, trauma analysis, and other methods used to produce biological profiles; the role of the forensic anthropologist in mass fatality incidents has become more prominent and its contribution continues to be recognised (e.g., Hinkes, 1989; Kahana and Hiss, 2009; Mundorff, 2008, 2011; Dirkmaat, 2012; de Boer et al., 2019).

This paper considers the role of forensic anthropologists in mass fatality incidents, highlighting the value and the information that forensic anthropology can provide. A review of the work undertaken by forensic anthropologists is followed by an exploration into some of the different scenarios encountered in mass disasters and the process of disaster victim identification (DVI). The specific role of the anthropologist in these incidents and the relationship with DNA analysis and positive identification is also explored (see also Cattaneo et al., 2010; Goodwin, 2017; Alonso et al., 2005; Mundorff et al., 2014).

THE ROLE OF THE FORENSIC ANTHROPOLOGIST

The participation of a forensic anthropologist in post-mortem examinations has varied historically and geographically depending on the country it is practised in, legislation, police structure and a number of other factors (Brickley and Ferllini, 2007; Márquez-Grant and Fibiger, 2011; Kranioti and Paine, 2011; Groen et al., 2015; Ubelaker, 2015; Márquez-Grant et al., 2016; Obertová et al., 2019). It is worth remembering that in some countries forensic anthropologists will have a medical and a forensic pathology background, whilst in others they will come from a biology, anatomy and anthropological (social, cultural,

biological, etc.) and/or archaeological background. Some practicing forensic anthropologists may also have undertaken police training and become police officers and/or crime scene investigators. This range in forensic anthropology practice can be observed throughout Europe (e.g. Kranjoti and Paine, 2011; Obertová et al., 2019). The relationship between archaeology and anthropology and how they overlap is also another matter than can be discussed (e.g., see also Blau and Ubelaker, 2016), especially if the anthropologist has an archaeological background; and, likewise, the boundary between anthropology and forensic pathology when the practicing anthropologist also has this medical background.

If for the purpose of this paper, we focus on the remains of the recently deceased (different time frames depending on the country), and leave aside the examination of historical remains or images of living individuals, the forensic (physical) anthropologist will work with human cadavers in various stages of decomposition. These could range from relatively fresh bodies (requiring access to bone via imaging or invasive autopsy, see, e.g., Leo et al., 2013; Brough et al., 2015), through to varying degrees of decomposition, mummification, burnt and charred remains, complete skeletons and small bone fragments (see forensic taphonomy literature, e.g., Boddington et al., 1987; Haglund and Sorg, 1996, 2001; Pokines and Symes, 2013; Schotsmans et al., 2017; Schmidt and Symes, 2015). Indeed, recently, casework undertaken by forensic anthropologists for age estimation (e.g., Rainwater et al., 2012) and trauma analysis (e.g., García Ruiz and Gutiérrez Buitrago, 2020) in particular, has been undertaken on fresh cadavers.

Following the literature (Komar and Buiscktra, 2008; Roberts and Márquez-Grant, 2012; Márquez-Grant, 2015), and with some additions and modifications, forensic anthropologists may be requested to undertake the following tasks (excluding training, education, research, validation, and proficiency testing), depending on their remit, the case and scenario:

1. Participate in and advise on the search, location and recovery of human remains, including large sieving operations.
2. Distinguish bone from any other material.
3. Identify bone as human or non-human.
4. Provide an inventory of the bone(s) and any missing elements.
5. Comment on antiquity of the bone if possible or on post-mortem interval; or if contemporary whether the bone(s) is an anatomical specimen, a museum exhibit, a trophy skull or from any other context.
6. Comment on minimum number of individuals (MNI) or maximum likelihood number of individuals (MLNI).
7. Provide information on the biological profile of the remains that may assist in the identity of the deceased: age-at-death, sex, ancestry, stature and any unique identifying traits where possible. These features could be anatomical variations, cultural deformation of the bones or pathological conditions. In addition, anthropologists in some countries may examine any medical implants or devices (e.g., Ubelaker et al., 2019b), whilst in others this is done by the pathologist or police.
8. Examine any aspects around the factors which have influenced the body after death (forensic taphonomy), or preservation of the remains, which may provide information on the deposition of the body, including for example differentiating between dismemberment by sharp force trauma and disarticulation of human remains by scavengers.
9. Assess trauma and provide opinion on whether it is peri-mortem injury or post-mortem damage or even anatomical variation (e.g., sternal aperture, large parietal foramen). With regard to trauma analysis, it should be noted that in most countries, whilst the forensic anthropologist may comment on the mechanism of injury or the damage on the bone, although it is the duty of the forensic pathologist or medical examiner to certify cause and manner of death.
10. Craniofacial reconstruction to assist in identification.
11. Sampling of bone and providing information on other possible analysis such as stable isotope analysis for provenance or radiocarbon dating.

12. Reconstruct the remains if fragmented in order to assess trauma, manage commingling, etc.
13. Attribute bones to a particular individual in cases of commingling.

In addition, the anthropologist will often assist with formulating strategies to maximise recovery of evidence from the bones, particularly environmental evidence, such as moss, barnacles, etc. that may assist with further information (e.g., Márquez-Grant and Roberts, 2012; Pokines and Symes, 2013). These requests are in addition to report and statement writing, providing advice on which related specialist areas might benefit an investigation, peer review, and expert witness testimony where applicable (e.g., Galloway et al., 1990). This may be within a criminal justice or humanitarian context and the anthropologist may be working with coroners, a team of law enforcement personnel, or lawyers acting on the behalf of a defendant. Of course, the questions that anthropologists can answer are dependent on the condition of the remains and not all are necessarily addressed in a single case. It may be that the medico-legal team has already identified the deceased and the only request for the anthropologist is to examine an area of damage to the skeleton to provide an opinion as to whether it is a fresh (peri-mortem) trauma or a dry (post-mortem) break.

Although achieving positive identification by using forensic anthropology alone is rare, it is true that in some cases the deceased have been positively identified from the assessment of non-metric traits on the skeleton and previous ante-mortem radiographs, or where frontal sinuses have been used in a similar way (Ubelaker et al., 2019; Steadman et al., 2006; Baraybar, 2008; Ross et al., 2016; Christensen, 2005). This, however, should be qualified by acknowledging that this is generally only accepted when other primary methods of identification have not been available (e.g., Olivieri et al., 2018). Examples of this might include absence of DNA reference samples or ante-mortem dental records (or indeed dentition), or simply lack of resources including funding. In such situations the forensic anthropologist can assist in the identification of

the deceased by liaising with families to obtain ante-mortem data (asking the right questions in view of the physical evidence) and assist relatives with viewing the deceased and interacting with relatives to explain the process, in particular in Human Rights cases (e.g., Mladina, 2016; see also Devisser et al., 2014; Anderson and Spradley, 2016; Wade, 2016). Ideally, however, this should only ever be done by experienced anthropologists who have had appropriate training in working with the bereaved. On occasions, sometimes the identification is provided by ID tags or markers or personal information within the graves and the anthropologist aims at checking whether the biological profile is consistent with that of the material, cultural and other documentation provided. One example of this is the dating of 'cemetery of the bottles' to the Spanish Civil War (Etxeberria et al., 2014).

The types of cases that forensic anthropologists may be engaged in are many and varied, and include the following:

- Search operations for missing persons.
- Fatal fires (domestic, workplace, vehicle, wildfire).
- Clandestine graves as a result of homicide.
- Burials undertaken by families following war crimes.
- Exhumations of unidentified bodies from cemeteries.
- Surface deposition sites (natural, accidental, suspicious, suicidal or unexplained deaths).
- Transportation accidents involving one individual or more.
- Industrial accidents (e.g., explosions, building collapse) involving one individual or more.
- Mass disasters from natural phenomena.
- Terrorist attacks.
- Cold case reviews.
- Age estimation in the living.
- Identification of the living.

The above (as seen similarly for forensic archaeology in Groen et al., 2015), would encompass cases for domestic police or law enforcement agencies, humanitarian cases with no judicial process, humanitarian cases with a

judicial process, and mass fatality incidents with criminal and no criminal involvement.

FORENSIC ANTHROPOLOGY WORK IN MASS FATALITY INCIDENTS

Mass disasters resulting in mass fatalities have been present throughout human history (Ziętkiewicz et al., 2012). Tragically too in recent years, these incidents have resulted in a few individuals to thousands of dead and missing presumed dead (Watherston et al., 2018; Alonso et al., 2005; de Boer et al., 2019). The definition of a mass fatality incident will vary between countries and between states or regions within each country, but it is widely accepted that it should not be based on the number of fatalities alone. The process of identifying the remains from mass fatality incidents tends to be in English, Disaster Victim Identification or DVI (e.g., Black et al., 2011). Factors such as resources of the host nation, experience and training of responders and the condition of the remains, including levels of fragmentation, commingling and burning, must be taken into account as they provide their own challenges. It is now well documented that an incident with a relatively small number of victims who are severely disrupted may raise more challenges than an incident with larger numbers of whole, unburnt bodies (e.g., Byard and Winskog, 2010; Winskog, 2012; Gunawardena et al., 2018; Ellis, 2019; de Boer et al., 2020).

Mass fatality incidents may be categorised as Closed or Open, although in reality they are most often a combination of the two types (e.g., Black et al., 2011). Closed incidents are where the identities of the deceased are known, for example in a military air crash where the names of the personnel on board would have been logged. An open incident is one in which the deceased could include anyone who might have been in the area at the time, for example, a bomb in an open market place. An example of a combined incident might be a civilian air crash, which landed on a busy motorway. It is clearly far easier to positively identify the deceased quickly in a closed incident, as DVI teams will know where to go and who to approach for DNA reference samples, ante-mortem dental records and/or

fingerprint data. It could be argued that the role of the forensic anthropologist is far greater in open incidents, where there is a need to collate information relating to the biological profiles of the deceased in order to provide a “starting point” for the identification process. This work would of course go hand in hand with police investigations to ascertain who may have been at the disaster site at the time of the incident. Even where the identity of the deceased is presumed, the forensic anthropologist can still play a vital role in the identification and repatriation process if remains are burnt and / or highly fragmented.

Many types of disasters, whether natural, terrorist attacks, industrial accidents, transportation incidents, arson, etc. have often led to charred, burnt and highly fragmented and commingled human skeletal remains. Where previously these body parts might have remained unidentified, the involvement of forensic anthropologists has shown that in some such cases, positive identifications can still be achieved. The work of the Interpol DVI Pathology and Anthropology Sub Working Group (PASWG), previously led by Dr Peter Ellis (e.g. Ellis, 2019) and now by Hans de Boer, has vastly improved the collaboration between forensic pathologists and anthropologists in the arena of DVI. Most recently this has led to the production of a series of policy documents, guidelines and recording forms designed specifically for use in incidents where there is a high volume of disrupted, commingled, fragmented and burnt remains, for example those developed by INTERPOL (<https://www.interpol.int/How-we-work/Forensics/Disaster-Victim-Identification-DVI>). Each country and regions within that country may have their own emergency response and DVI protocols. In the UK some guidelines have been produced by the Home Office (2004). As part of National DVI teams (such as UK DVI, or DMORT in the USA) whether civilian, police and / or military (such as Guardia Civil DVI Team in Spain), or as employees of independent forensic science providers or emergency response teams (private, governmental or other organisations such as United Nations or ICRC), forensic anthropologists have been involved in assisting with the management of the dead, their identification and providing information to loved

ones. They have been involved in training and capacity building in war torn areas, liaising with families for ante-mortem information on the deceased, scene and mortuary attendance, participating in identification commissions and finally providing further information to families (e.g., Carroll et al., 2017).

Examples of forensic anthropology participation in the DVI process worldwide in the last decades have included terrorist attacks (e.g. Prieto et al., 2007; Kahana et al., 1997; Hiss and Kahana, 2000; MacKinnon and Mundorff, 2006; Buck and Briggs, 2016; Quatrehomme et al., 2019) natural disasters including tsunamis, wildfires or earthquakes (Cordner et al., 2011; Blau and Briggs, 2011; Black, 2016; Beauthier et al., 2009; Leditschke et al., 2009; Gin et al., 2020), transportation accidents such as air crashes, road traffic collisions, cable car and rail accidents (e.g. Hinkes, 1989; Saul and Saul, 2003; Dirkmaat, 2012; Cattaneo et al., 2015; Barbería et al., 2015), industrial accidents such as gas explosions, building collapse and fatal fires caused by accident or arson (e.g. Park et al., 2009; Rutty et al., 2020), amongst others (e.g. Ubelaker et al., 1995). In addition, it has been reported that more than 20,000 migrants have died trying to cross the Mediterranean since 2014 and many remain unidentified and buried in unmarked graves (Olivieri et al., 2018; Dearden et al., 2020). In other areas such as the Mexico-US borders, anthropologists have a significant role in assisting with the identification of the deceased (e.g., Fleischman et al., 2017). Violence on a mass scale such as genocide and burial of victims in mass graves (e.g., Groen et al., 2015; Ferllini and Croft, 2009; Mohd Noor et al., 2017) also constitute mass fatality incidents but they are not the focus of this paper.

Finally, in light of the recent COVID-19 pandemic, a number of forensic (physical) anthropologists have also been working on protocols for the management of the dead during this pandemic, aiming to provide as much dignity and respect as possible to both the dead and their relatives (e.g., Finegan et al., 2020, and also the Argentine Forensic Anthropology Team or EAAF in its Spanish acronym, eaaf.org).

Below we have summarised the most frequent tasks in which the forensic anthropologist might

be involved at the mass disaster site and in the mortuary. These may vary according to the scope and nature of the incident and the resources of the host nation. It must be emphasised that this work is collaborative and would be undertaken within a team of pathologists, odontologists, fingerprints experts, archaeologists, radiographers, DVI trained police officers and emergency response teams. In England and Wales for example, the way in which these teams will be organised and the order in which the specialist examinations will take place, should be decided by Coroner (or other judicial authority leading the operation), the Senior Identification Manager (SIM), the Scene Evidence Recovery Manager (SERM) and the Police Mortuary Coordinator (PMOC) in consultation with the relevant experts (Interpol, 2018). All the tasks described below would be carried out within the framework of the Interpol DVI Guide (2018).

THE FORENSIC ANTHROPOLOGIST AT THE MASS FATALITY SCENE

Anthropology can assist with multiple lines of inquiry (Figura, 2018; Olivieri et al., 2018) in both large and small incidents, (Wiersema and Woody, 2016).

Search and Recovery of Human Remains

- Working within the multidisciplinary team described above and utilising Interpol DVI protocols (Interpol, 2018), the forensic anthropologist can assist by:
- Advising on how to set up the search grid, including reaching a decision on the most appropriate size of grid squares. This would depend on the level of fragmentation and dispersal of remains, which in turn might vary in different parts of the scene. He or she may also advise on the likely survival of remains and produce a forensic taphonomy report if required. This may be in relation to preservation in mass graves, or the likelihood that body parts will have survived intense heat and/or a large explosion.
- Assisting with strategies for sieving debris, supervising or conducting sieving operations and examining recovered items to determine whether they are human bone. If it is not possible

to do this directly, the anthropologist can provide awareness training for police officers and CSIs who may be undertaking sieving operations (Nannetti, 2020), and later review any material that has been recovered.

- Assisting with the recognition of smaller body parts and bone fragments at the scene, particularly where they are modified, for example small fragments of calcined (completely burnt) bone. It is important to consider here that in some scenarios, only one or very few small fragments of bone might be all that is left (or recovered) from an individual, therefore it is essential that they are identified, recorded and recovered correctly.

Correct recording of the remains *in situ* at the scene is particularly important in a mass fatality incident for re-assignment of body parts and fragments where it is apparent that it will not be possible to obtain a DNA profile. Accurate recording of distribution patterns at the scene may also be vital for subsequent accident or criminal investigations, coroners' inquests, public and private inquiries (de Boer et al., 2020).

In terms of the collection and packaging of small fragments, the anthropologist can advise on use of Unique Reference Numbers (URN) at the scene, also referred to as post-mortem (PM) numbers. There is often uncertainty surrounding whether to group very small fragments together and collect them under a single URN or whether to still attempt to assign each tiny fragment its own number. An informed judgement can be made in relation to this by the anthropologist, who will consider which elements are represented and whether there are any genuine associations between the fragments (Interpol, 2018).

In addition to assisting with the completion of the Interpol Victim Recovery Booklets, the forensic anthropologist / archaeologist might record the remains at a mass fatality scene in a number of ways, depending on the resources available and the type of scene being recorded.

Methods include:

- Tape measurements within grids and zones and production of scale drawings.
- Survey using a Total Station or Theodolite.

- Survey-grade GPS.
- Georectified photography and photogrammetry.
- UAV survey.

Often a number of the above methods will be combined, for example photogrammetry and Total Station survey is particularly useful for recording complex fatal fire scenes, where they can illustrate the location of body parts within different levels of building collapse and debris (Dirkmaat, 2012; Schmitt et al., 2015). This is not only useful for post-incident reconstruction of the site and presentation of evidence in court or at inquests, it can assist with the interpretation of events including the whereabouts of the deceased at the time they died.

Special consideration needs to be given to burnt remains, as they are often highly fragmented and fragile. They may be dispersed over a wide area or mixed in with other material such as building debris or the burnt interior of an aeroplane. This together with the fact that intense heat can alter the size, colour and shape of body parts and bones means that recognition of burnt remains is often difficult (de Boer et al., 2020).

If remains are burnt to the point where they become calcined (white, brittle and with no organic material surviving) then it will not be possible to extract DNA from them (Symes et al., 2015; Devlin and Herrman, 2015). In these situations, observations at the scene become very important, particularly with regard to the position of fragments and correct identification, as this information can assist with the reconciliation process, and this is where forensic anthropology specialism is important.

Quality assurance and triage are vitally important at the scene. The forensic anthropologist can assist by reviewing the victim recovery forms accompanying body parts before body bags are sealed and they leave the scene, in order to ensure that the descriptions of remains are correct and accurate sketch plans of locations have been completed.

The experienced forensic anthropologist is also qualified to make a judgement on prioritization of body parts for examination and collection of DNA samples in the mortuary, based on many

factors including the type and size of part, level of disruption, contamination and degradation, and presence of identifying features. This information can be passed to the mortuary team prior to the arrival of the part, which can assist with decisions relating to triage and the order in which DNA samples are submitted to the forensic laboratory. Forensic anthropologists and DNA scientists have adopted an increasingly collaborative approach in recent years and this has had a positive impact on DNA success rates and positive identifications (e.g., Mundorff et al., 2014; de Boer et al., 2019; Gin et al., 2020).

The forensic anthropologist may provide preliminary information about the estimated (minimum) number of individuals involved in the mass fatality incident, based on counting repeated skeletal elements (bones) or body parts and the identification of individuals of different sex and age. Caution must be exercised with regard to these preliminary observations, however, and they should only be regarded as an initial guide, subject to confirmation in the mortuary and where possible the DNA laboratory.

The forensic anthropologist in the mortuary

Post mortem examinations may be conducted in a DVI-designated permanent mortuary or a temporary mortuary set up specifically for the

mass fatality incident (Anderson et al., 2017; Interpol, 2018). Figure 1 shows a standard workflow pattern through the mortuary during a mass fatality incident. From this, it can be seen that the anthropologist may be engaged at several stages in the process, and in particular during the image analysis prior to opening the body bag and during the examination of the remains.

In some cases, a separate mortuary specifically for anthropological cases may be designed, or areas within an existing mortuary may be adapted for anthropological examination. Some mortuaries will also have a triage area where the anthropologist may separate human from non-human bone or non-bone material, before it enters the post mortem examination room. As such, the forensic anthropologist must have a good working knowledge of mortuary procedures, including the measures required to minimise contamination. Specific tasks that the forensic anthropologist can assist with in the mortuary include the following:

- Identification of body parts, particularly where they are small, incomplete and / or burnt. This can be done by examination of CT scans and radiographs as well as by examination of the remains themselves (Rutty et al., 2020; Brough et al., 2015). In a mass fatality situation where there is a high throughput of badly disrupted remains, CT scanning can reduce the amount

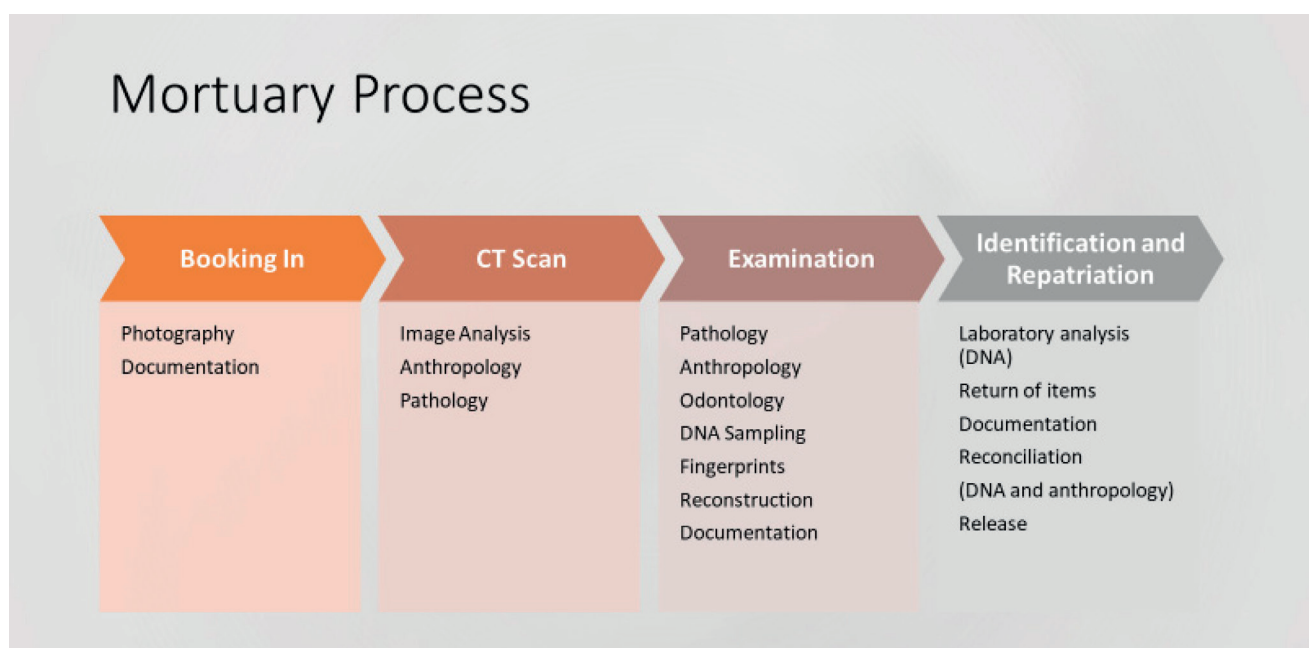


Fig. 1.- Workflow through the mortuary in a mass fatality incident.

of dissection required. Layers of tissue can be virtually removed so that bones can be visualised within masses of soft tissue, enabling the anthropologist to establish what is present or absent. This can also be useful for working out which side the body part is from, therefore assisted with calculation of numbers of individuals. It is possible to rotate the images if a different view is required and to recall images at a later date for further clarification or use in statement writing.

- Completion of Interpol or DVI post-mortem forms plus production of supplementary detailed records, including an inventory of smaller / burnt fragments. This information can later be used in summary victim reports and body maps (see below).
- Provision of a “running total” of minimum numbers of individuals based on count of repeated bones and taking into account age and sex differences.
- Provision of advice on best samples for DNA analysis, particularly in burnt, fragmented and / or degraded remains.
- Collection of DNA samples in the absence of the pathologist, or in addition to the pathologist depending on resources available, number of workstations in operation and examinations in progress.
- Recording of DNA samples prior to destruction.
- Provision of biological data which can assist with identification of the deceased
- Physical reconstruction of remains for the purpose of identification, e.g., re-joining burnt fragments which are not suitable for DNA with unburnt fragments which can be tested, from the same individual, thus also minimising the amount of samples required for DNA analysis.
- Re-association of remains to one particular individual or element identified by either DNA or odontology. This may be done via articulation, visual pair-matching, physical fits, biological profile consistency and thus minimising any ‘common tissue’ and providing more remains to the family.
- Physical reconstruction of remains to assess and interpret defects, e.g., gunshot wounds or trauma caused by explosive devices.

Following the post-mortem examination, the forensic anthropologist can liaise with the DNA scientists to reconcile DNA results with sample type taken and the source of the sample. If an accurate description of the body part or fragment from which the sample was derived has been made, then the forensic anthropologist can produce a “body map” of all the parts tested from each individual. This can be presented in a 2D or 3D paper or digital format depending on the requirement of the investigation or inquiry. The forensic anthropologist can also produce summary reports for each victim, which include the body map, plus a table of body parts identified presented in scientific and non-scientific terminology. If they wish, families of the deceased can be shown this information by specially trained officers in preference to viewing the remains themselves or photographs of the remains.

DNA AND FORENSIC ANTHROPOLOGY

Although DNA is now the primary means of identification in mass fatality incidents (e.g. Watherston et al., 2018), and this has caused a paradigm shift in the field (Dirkmaat et al., 2008), there is still much value in having an anthropologist in the DVI team (see also Mundorff, 2009, 2012; De Boer et al., 2019). Here is a final summary of the contribution it can make:

- a. Identification of whether material is bone and, if bone, whether it is human. This can certainly save a lot of time, resources and money. This may be better in the sieving stage or triage stage where the anthropologist, skilled in bone identification and in bone in different states of decomposition, can identify the bone as human. This is such an important skill, as in some cases what is left of one person is only one fragment of bone which has been retrieved.
- b. Assistance with establishing a minimum number of individuals present. At times, in open incidents or even in closed incidents, there may have been someone unaccounted for. It is possible that forensic anthropologists may identify an additional person by repeated bone counts and/or different biological profile.

- c. Production of biological profiles where there are no suitable DNA or dental reference samples available for comparison.
- d. Production of biological profiles of the deceased when DNA cannot be retrieved from the remains and where there is no other evidence. For example, in calcined remains of an infant with no dental work or an adult with no dental or fingerprint records.
- e. Reconstruct bones from several fragments in order to minimise DNA sampling and submit only one fragment for testing.
- f. Recording the bone prior to DNA sampling and destruction.
- g. In rare cases of identical twins, if skeletal pathologies or unique features were present and ante-mortem medical records were available.
- h. Other information beyond identification, such as skeletal trauma analysis, including interpretation of injury patterns in blast trauma. This can provide additional physical evidence relating to the detonation of explosive devices in terrorist investigations.
- i. With regard to ethics, ensuring as much bone reassociation as possibly has been achieved in order to minimise the amount of 'common tissue' remaining at the end of an operation.
- j. Liaison with relatives in some humanitarian contexts and management of their expectations, especially with regard to DNA analysis and repatriation of remains (Aronson, 2016; Wade, 2016; Etxeberria Gabilondo, 2007, 2012; Ritter, 2007; Byrd and Adams, 2016, Sledzik and Mundorff, 2016; Wagner, 2014).

Table 1 summarises the tasks which the forensic anthropologist might undertake, divided in categories: i) specialist examinations ii) supervision of police / CSI teams or military officers during large search and recovery operations, iii) documentation of work, iv) acting in a managerial capacity. This has been taken from the literature cited above and the authors' casework experience.

ENGAGING THE SERVICES OF A FORENSIC ANTHROPOLOGIST

In the UK, there are no longer any government owned and funded forensic laboratories, so a request to engage the services of a forensic anthropologist might come via a number of routes. In domestic casework this includes:

1. A direct request from the police (the Senior Investigating Officer, Crime Scene Manager, Forensic Services Manager, or Submissions Officer), to a Forensic Service Provider (laboratory) or individual Forensic Anthropologist.
2. Referral or request from a Forensic Pathologist or Odontologist.
3. Referral through the National Crime Agency (NCA) Special Operations Help Desk.
4. Request from a solicitor acting on behalf of a client.

In the case of a mass fatality incident, again, there are several routes:

1. Direct request by a UK police force to a contracted forensic service provider.
2. Request from a UK police force via another agency such as the NCA.
3. UK DVI (the national capability of the UK police service to respond to mass fatality incidents in the UK and overseas when requested by HM Government), particularly if it is an international incident in which British citizens have died.
4. Other agencies, e.g., repatriation companies such as Blake Emergency Services or Kenyon International Emergency Services.

If the request comes from UK DVI, this will go to the UK DVI anthropology point of contact who will coordinate the response.

It is the responsibility of the authority engaging the services of the forensic anthropologist to ensure that they are able to demonstrate their competence, and comply with the requirements of the UK Criminal Justice System (CJS) if the request is to assist with a criminal investigation.

Table 1. Forensic Anthropology Tasks

Specialist Examinations	Supervision	Documentation	Management and Coordination
Species and fragment identification	Line or fingertip searches	Recording remains at the scene: location, position, elements present, damage	Liaison and collaboration with other experts at scene and mortuary
Biological profile (estimation of age, sex, ancestry, stature and individuating features)	Sieving operations- sifting large amounts of material for human tissue	Creation of a skeletal inventory	Liaison with police, judiciary, solicitors, government agencies and NGOs
Estimation of postmortem interval/ time since burial or deposition	Directing CSI/police photographers to capture images required at scene and in mortuary	Documentation of examinations	Case file management; compliance with requirements of CJS and UKAS (in the UK)
Interpretation of traumatic injuries	Supervision of technical assistants and junior colleagues in the laboratory, e.g. exhibit handling, photography, preparation of slides and samples, documenting procedures	Production of specialist report or witness statement	Liaison with forensic laboratories, in particular DNA scientists
Interpretation of thermal damage		Production of presentations for court	Ensuring compliance with quality management systems at all stages of involvement in a case
Classification of postmortem modification, e.g. scavenger activity		Maintenance of portfolio for proof of competency and, if applicable, professional certification	
Microscopy: LPM, HPM, SEM, histology			
Selection of DNA samples			
Physical or virtual reconstruction of fragmented remains			
Specialist image analysis in the living or deceased: age at death, growth and development studies, skeletal indicators of stress			

CONCLUSIONS

This paper has briefly re-examined the role of forensic anthropology and its definition in the first quarter of the 21st century. It can be seen that forensic anthropology can often play a pivotal role, particularly when mass disasters tragically occur, and this has been recognised by its inclusion as a key discipline in Annexure 17 of the Interpol DVI Guide 2018. The annexure states that *“As the complexity of a disaster scene increases, so does the need to employ a broader range of expertise. DVI investigations benefit from the involvement of FAs because disasters are often characterized by compromised or highly fragmented human remains and decreased states of preservation”* (Interpol, 2018). It also emphasises that whilst

the forensic anthropologist is *“an integral part of the multidisciplinary DVI team, in scenarios resulting in fragmented and/or compromised remains”* it is vital that the FA operates in collaboration with the rest of the DVI team and liaises closely with the DVI-operation manager (*ibid*). The latter is an important point, as working within a multidisciplinary team on a DVI operation requires a very different approach to undertaking domestic forensic casework. In this sense, mentoring and training for forensic anthropologists who wish to become involved in DVI work is vitally important, and this perhaps needs to be reviewed in the near future.

Many mass fatality incidents will unfortunately result in multiple commingled body parts and burnt fragmented remains. Recovery of these

remains and selection of samples for DNA is entirely different from dealing with whole unburnt bodies or body parts. The forensic anthropologist is specifically trained in the recognition and recovery of these body parts, especially if too degraded and fragmented, providing a representation of the number of individuals, assistance with reconstruction and repatriation, obtaining samples for DNA analysis if no other specialist is present.

The importance of continual professional development (CPD) must also be recognised by forensic anthropologists who regularly provide assistance to the courts in criminal investigations. It is vital that the practitioner is familiar with the latest research and developments in the field in order to provide the best service possible, and so CPD should be seen as a necessity and not an afterthought. This should include exercises regarding temporary mortuary set ups, and completing INTERPOL forms, etc. Moving forward, closer collaborations between forensic laboratories and academic institutions providing research and teaching in forensic anthropology, can only serve to strengthen the discipline and further augment its position alongside the more traditional branches of forensic medicine and science.

REFERENCES

- ABFA (2018) <http://theabfa.org/>
- ALONSO A, MARTÍN P, ALBARRÁN C, GARCÍA P, FERNÁNDEZ DE SIMÓN L, ITURRALDE MJ, FERNÁNDEZ-RODRÍGUEZ A, ATIENZA I, CAPILLA J, GARCÍA-HIRSCHFELD J, MARTÍNEZ P, VALEJO G, GARCÍA O, GARCÍA E, REAL P, ÁLVAREZ D, LEÓN A, SANCHO M (2005) Challenges of DNA profiling in Mass Disaster investigations. *Croat Med J*, 46: 540-548.
- ANDERSON M, LEDITSCHKE J, BASED R, CORDNER SM, DRUMMER OH (2017) Mortuary operations following mass fatality natural disasters: a review. *Forensic Sci Med Pathol*, 13: 67-77.
- ANDERSON BE, SPRADLEY MK (2016) The role of the anthropologist in the identification of migrant remains in the American Southwest. *Acad Forensic Pathol*, 6: 432-438.
- ARONSON JD (2016) *Who Owns the Dead? The Science and Politics of Death at Ground Zero*. Harvard University Press, Cambridge
- BARAYBAR JP (2008) When DNA is not available, can we still identify people? Recommendations for best practice. *J Forensic Sci*, 53: 53-540.
- BARBERÍA E, MARTIN-FUMADÓ C, GALTÉS I, SUBIRANA-DOMENECH M, PUIGBARRACA L, VIDAL-GUTIÉRREZ C, VALVERDE-VILLARREAL JL, CASTELLÀ-GARCIA J, MEDALLO-MUÑIZ (2015) Managing the identification of the mortal victims run over by a train in the Castelldefels railway accident (Barcelona). *Legal Med*, 17: 366-370.
- BARONE PM, GROEN WJM (eds) (2018) *Multidisciplinary Approaches to Forensic Archaeology: Topics Discussed during the European Meetings on Forensic Archaeology (EMFA)*. Springer, Cham.
- BEAUTHIER JP, DE VALCK E, LEFEVRE P, DE WINNE J (2009) Mass disaster victim identification: the Tsunami Experience. *The Open Forensic Sci J*, 2: 54-62.
- BEH P, PAYNE-JAMES J (2010) Clinical and legal requirements for age determination in the living. In: Black SM, Aggrawal A, Payne-James J (eds). *Age Estimation in the Living: The Practitioner's Guide*. Wiley-Blackwell, Chichester, pp 30-42.
- BLACK S (2016) Disaster Anthropology: The 2004 Asian Tsunami. In: Blau S, Ubelaker DH (eds). *Handbook of Forensic Archaeology and Anthropology*. 2nd edn. Routledge, Abingdon, pp 397-406.
- BLACK SM, AGGRAWAL A, PAYNE-JAMES J (eds) (2010) *Age Estimation in the Living: The Practitioner's Guide*. Wiley-Blackwell, Chichester.
- BLACK S, SUNDERLAND G, HACKMAN L, MALLETT X (2011) *Disaster Victim Identification: Experience and Practice*. CRC Press, Boca Raton, FL.
- BLAU S (2005) One chance only: advocating the use of archaeology in search, location and recovery at disaster scenes. *Australian J Emerg Manag*, 20: 19-24.
- BLAU S (2009) More than just bare bones: ethical considerations for forensic anthropologists. In: Blau S, Ubelaker DH (eds). *Handbook of Forensic Archaeology and Anthropology*. Routledge, Abingdon, pp 457-467.
- BLAU S (2016a) More than just bare bones: ethical considerations for forensic anthropologists. In: Blau S, Ubelaker DH (eds) *Handbook of Forensic Archaeology and Anthropology*. 2nd ed. Routledge, Abingdon, pp 593-606.
- BLAU S (2016b) La ética y el antropólogo forense: una variedad de consideraciones. In: Sanabria-Medina C (ed). *Patología y Antropología Forense de la Muerte: La Investigación Científico-Judicial de la Muerte y la Tortura, Desde las Fosas Clandestinas, hasta la Audiencia Pública*. Forensic Publisher, Bogotá, pp 25-36.
- BLAU S (2018) It's all about the context: reflections on the changing role of forensic anthropology in medico-legal death investigations. *Australian J Forensic Sci*, 50: 628-638.
- BLAU S, BRIGGS CA (2011) The role of forensic anthropology in Disaster Victim Identification (DVI). *Forensic Sci Int*, 205: 29-35.
- BLAU S, UBELAKER DH (eds) (2016) *Handbook of Forensic Archaeology and Anthropology*. 2nd Ed. Routledge, Abingdon.
- BODDINGTON A, GARLAND AN, JANAWAY RC (eds) (1987) *Death, Decay and Reconstruction: Approaches to Archaeology and Forensic Science*. Manchester University Press, Manchester.
- BRICKLEY MB, FERLLINI R (2007) *Forensic Anthropology: Case Studies from Europe*. Charles C. Thomas, Springfield IL.
- BROUGH AL, MORGAN B, RUTTY GN (2015) The basics of disaster victim identification. *J Forensic Radiol Imag*, 3: 29-37.
- BUCK AM, BRIGGS CA (2016) The role of the anthropologist in Disaster Victim Identification: Case studies from the 2002 and 2004 terrorist attack in Bali, Indonesia. In: Blau S, Ubelaker DH (eds). *Handbook of Forensic Archaeology and Anthropology*. 2nd Ed. Routledge, Abingdon, pp 520-531.
- BURKE P (2011) *Law's Anthropology: From Ethnography to Expert Testimony in Native Title*. The Australian National University Press, Canberra.
- BYARD R, WINSKOD C (2010) Potential problems arising during international disaster victim identification (DVI) exercises. *Forensic Sci Med Pathol*, 6: 1-2.
- BYRD J, ADAMS BJ (2016) Analysis of Commingled Human Remains. In: Blau S, Ubelaker DH (eds). *Handbook of Forensic Archaeology and Anthropology*, 2nd Ed. Routledge, Abingdon, pp 238-239.
- CARROLL E, JOHNSON A, DEPAOLO F, ADAMS BJ, MAZONE D, SAMPSON B (2017) Trends in United States mass fatality incidents and recommendations for medical examiners and coroners. *Acad Forensic Pathol*, 7: 318-329.

- CATTANEO C (2007) Forensic anthropology: Developments of a classical discipline in the new millennium. *Forensic Sci Int*, 165: 185-193.
- CATTANEO C, DE ANGELIS G, GRANDI M (2005) Mass disasters. In: Schmitt A, Cunha E, Pinheiro J (eds). *From Forensic Anthropology and Medicine: Complementary Sciences From Recovery to Cause of Death*. Humana Press Inc., Totowa NJ, pp 431-443.
- CATTANEO C, PORTA D, DE ANGELIS D, GIBELLI D, POPPA P, GRANDI M (2010) Unidentified bodies and human remains: An Italian glimpse through a European problem. *Forensic Sci Int*, 19: 167.e1-167.e6.
- CHRISTENSEN AM (2005) Testing the reliability of frontal sinuses in positive identification. *J Forensic Sci*, 50: 18-22.
- CORDNER S, TIDBALL-BINZ M (2017) Humanitarian forensic action – Its origins and future. *Forensic Sci Int*, 279: 65-71.
- CORDNER SM, WOODFORD N, BASSED R (2011) Forensic aspects of the 2009 Victorian Bushfires Disaster. *Forensic Sci Int*, 205: 2-7.
- COX M, LOE L, JONES P (2016) Fromelles: forensic archaeology and anthropology in identification. In: Blau S, Ubelaker DH (eds). *Handbook of Forensic Archaeology and Anthropology*. 2nd Ed. Routledge, Abingdon, pp 575-606.
- CROWDER CM, WIERSEMA JM, ADAMS B J, AUSTIN DE, LOVE JC (2016) The utility of forensic anthropology in the medical examiner's office. *Acad Forensic Pathol*, 6: 349-360.
- DEARDEN K, SÁNCHEZ DIONIS M, BLACK J, LACZKO F (2020) Calculating "Death Rates" in the Context of Migration Journeys" Focus on the Central Mediterranean. GMDAC Briefing Series: Towards safer migration on the Central Mediterranean Route. Publications unit of the International Organisation for Migration publication. <https://missingmigrants.iom.int/region/europe> Last update 24th April 2020 [accessed 26/04/2020].
- DE BOER HH, BLAU S, DELABARDE T, HACKMAN L (2019) The role of forensic anthropology in disaster victim identification (DVI): recent developments and future prospects. *Forensic Sci Res*, 4: 303-315.
- DE BOER HH, ROBERTS J, DELABARDE T, MUNDORFF AZ, BLAU S (2020) Disaster victim identification operations with fragmented, burnt, or commingled remains: experience-based recommendations. *Forensic Sci Res*, 5(3): 191-201.
- DEVISSER EM, LATHAM KE, INTRIAGO LEIVA M (2014) The contribution of forensic anthropology to national identity in Chile: a case study from Patio 29. In: Martin DL, Anderson CP (eds). *Bioarchaeological and Forensic Perspectives on Violence: How Violent Death is Interpreted from Skeletal Remains*. Cambridge University Press, Cambridge, pp 216-235.
- DEVLIN JB, HERRMANN NP (2015) Bone Colour. In: Schmidt CW, Symes SA (eds.). *The Analysis of Burned Human Remains*. 2nd ed. Academic Press, London, pp 119-138.
- DIRKMAAT DC (2012) Forensic anthropology at the mass fatality incident (commercial airliner) crash scene. In: Dirkmaat DC (ed). *A Companion to Forensic Anthropology*. John Wiley & Sons, Chichester, pp 136-156.
- DIRKMAAT DC, CABO LL, OUSLEY SD, SYMES SA (2008) New perspectives in forensic anthropology. *Yearb Phys Anthropol*, 51: 33-52.
- DUPRAS TL, SCHULTZ JJ, WHEELER SM, WILLIAMS LJ (2012) *Forensic Recovery of Human Remains: Archaeological Approaches*. 2nd Ed. CRC Press, Boca Raton FL.
- ELLIS P (2019) Modern advances in disaster victim identification. *Forensic Sci Res*, 4: 291-292.
- EMANOVSKY PD, BELCHER WR (2012) The many hats of a recovery leader: perspectives on planning and executing worldwide forensic investigations and recoveries at the JPAC Central Identification Laboratory. In: Dirkmaat DC (ed). *A Companion to Forensic Anthropology*. John Wiley & Sons, Chichester, pp 567-592.
- ETXEBERRIA GABILONDO F (2007) Las exhumaciones de la Guerra Civil Española desde una perspectiva antropológica y paleopatológica. In: Barca Durán J, Jiménez Ávila J (eds). *Enfermedad, Muerte y Cultura en las Sociedades del Pasado Volumen II*. Fundación Academia Europea de Yuste, Cáceres, pp 538-551.
- ETXEBERRIA GABILONDO F (ed) (2012) *Antropología Forense de la Guerra Civil Española*. Boletín Galego de Medicina Legal e Forense 18. Asociación Galega de Médicos Forenses, Santiago de Compostela.
- ETXEBERRIA GABILONDO F, PLA LARRAMENDI K, QUEREJETA E (2014) *El Fuerte de San Cristóbal en la Memoria: de Prisión a Sanitorio Penitenciario. El Cementerio de las Botellas*. Editorial Pamiela, Pamplona.
- FERLLINI R (2007) *Forensic Archaeology and Human Rights Violations*. Charles C. Thomas, Springfield IL.
- FERLLINI R, CROFT AM (2009) The case of an Armenian mass grave. *J Hum Rights*, 8: 229-244.
- FIGURA BJ (2018) Advances in disaster victim identification. In: Latham KE, Bartelink EJ, Finnegan M (eds). *New perspectives in Forensic Human Skeletal Identification*. Academic Press, London, pp 333-341.
- FINEGAN O, FONSECA S, GUYOMARC ' H P, MORCILLO MENDEZ MD, RODRIGUEZ GONZALEZ J, TIDBALL-BINZ M, WINTER KA (2020) International Committee of the Red Cross (ICRC): General guidance for the management of the dead related to COVID-19. *Forensic Sci Int: Synergy*, 2: 129-137.
- FLEISCHMAN JM, KENDELL AE, EGGERS CC, FULGINITI LC (2017) Undocumented border crosser deaths in Arizona: expanding intrastate collaborative efforts in identification. *J Forensic Sci*, 62: 840-849.
- FRANCE D (2012) Ethics in forensic anthropology. In: Dirkmaat D (ed). *A Companion to Forensic Anthropology*. Wiley-Blackwell, Chichester, pp 666-682.
- GALLOWAY A, BIRKBY WH, KAHANA T, FULGINITI L (1990) Physical anthropology and the law: legal responsibilities of forensic anthropologists. *Yearb Phys Anthropol*, 33: 39-57.
- GARCÍA RUIZ AB, GUTIÉRREZ BUITRAGO G (2020) Multifocal approach in forensic pathology: radiological and anthropological correlation of defensive wounds by sharp weapon. Boletín Galego de Medicina Legal e Forense, 26: 79-93.
- GIN K, TOVAR J, BARTELINK EJ, KENDELL A, MILLIGAN C, WILLEY P, WOOD J, TAN E, TURINGAN RS, SELDEN RF (2020) The 2018 California Wildfires: integration of rapid DNA to dramatically accelerate victim identification. *J Forensic Sci*, 65: 791-799.
- GOODWIN WH (2017) The use of forensic DNA analysis in forensic action: The development of a set of international standards. *Forensic Sci Int*, 278: 221-227.
- GROEN M, MÁRQUEZ-GRANT N, JANAWAY R (eds) (2015) *Forensic Archaeology: A Global Perspective*. Wiley-Blackwell., Chichester.
- GUNAWARDENA, SA, SAMARANAYAKE R, DIAS V, PRANAVAN S, MENDIS A, PERERA J (2018) Challenges in implementing best practice DVI guidelines in low resource settings: lessons learnt from the Meethotamulla garbage dump mass disaster. *Forensic Sci Med Pathol*, 15: 125-130.
- GUYOMARC ' H P, CONGRAM D (2017) Mass fatalities, mass graves, and the forensic investigation of international crimes. In: Langley NR, Tersigni-Tarrant MTS (eds.). *Forensic Anthropology: A Comprehensive Introduction*. 2nd ed. CRC Press, Boca Raton FL, pp 335-345.
- HALGUND WD, SORG MH (eds) (1996) *Forensic Taphonomy: The Post-mortem Fate of Human Remains*. CRC Press, Boca Raton FL.
- HAGLUND WD, SORG MH (eds) (2001) *Advances in Forensic Taphonomy: Method, Theory and Archaeological Perspectives*. CRC Press, Boca Raton FL.
- HINKES MJ (1989) The role of forensic anthropology in mass disaster resolution. *Aviat Space Environ Med*, 60: A60-A63.
- HISS J, KAHANA T (2000) Trauma and identification of victims of suicidal terrorism in Israel. *Mil Med*, 165: 889-893.
- HOLDEN L (2019) Beyond anthropological expert witnessing: toward an integrated definition of cultural expertise. *Cultural Expertise and Socio-Legal Studies*, 78: <https://doi.org/10.1108/S1059-433720190000078010>

- HUNTER J, COX M (2005) *Forensic Archaeology: Advances in Theory and Practice*. Routledge, London.
- HOME OFFICE (2004) Guidance for dealing with fatalities in emergencies. *Home Office Communications Directorate*, London.
- HUNTER J, SIMPSON B, STURDY COLLS C (2013) *Forensic Approaches to Buried Remains*. Wiley-Blackwell, Chichester.
- INTERPOL (2018) *INTERPOL-disaster victim identification guide 2018* https://www.interpol.int/en/content/download/589/file/18Y1344_DVI_Guide.pdf [Accessed 26/04/2020].
- INTERPOL (2018) Annexure 17: Roles and Responsibilities of the Forensic Anthropologist for DVI. *INTERPOL-disaster victim identification guide*. https://www.interpol.int/en/content/download/589/file/18Y1344_DVI_Guide.pdf [Accessed 27/04/2020].
- IŞCAN MY, STEYN M (2013) *The Human Skeleton in Forensic Medicine*. 3rd edn. Charles C. Thomas, Springfield IL.
- KAHANA T, HISS J (2009) The role of forensic anthropology in mass fatality incidents management. *Forensic Sci Policy & Manag: An International J*, 1: 144-149.
- KLEPINGER L (2006) *Fundamentals of Forensic Anthropology*. John Wiley & Sons, Hoboken NJ.
- KOMAR DA, BUIKSTRA JE (2008) *Forensic Anthropology: Contemporary Theory and Practice*. Oxford University Press, New York.
- KRANIOTI EF, PAINE RR (2011) Forensic anthropology in Europe: an assessment of current status and application. *J Anthrop Sci*, 89: 71-92.
- LEDITSCHKE J, COLLETT S, ELLEN R. (2011). Mortuary operations in the aftermath of the 2009 Victorian bushfires. *Forensic Sci Int*, 205: 8-14.
- LEI G, LIU F, LIU P, ZHOU Y, JIAO T, DANG Y-H (2019) Worldwide tendency and focused research in forensic anthropology: A bibliometric analysis of decade (2008-2017). *Leg Med*, 37: 67-75.
- LEO C, O'CONNOR JE, MCNULTY JP (2013) Combined radiographic and anthropological approaches to victim identification of partially decomposed or skeletal remains. *Radiography*, 19: 353-362.
- LOE L, BARKER C, BRADY K, COX M, WEBB H (2014) 'Remember Me to All': The Archaeological Recovery and Identification of Soldiers Who Fought and Died in the Battle of Fromelles 1916. *Oxford Archaeology Monographs*, Oxford.
- LOVIS WA (1992) Forensic archaeology as mortuary anthropology. *Soc Sci Med*, 34: 113-117.
- MAPLES WR (1980) The practice of forensic physical anthropology. *Florida Scientist*, 43: 238-243.
- MÁRQUEZ-GRANT N (2015) Age estimation in forensic anthropology: perspectives and practical considerations. *Ann Hum Biol*, 42: 306-320.
- MÁRQUEZ-GRANT N (2018) The increasing role of the forensic anthropologist in the search for the missing. In: Barone PM, Groen M (eds). *Multidisciplinary Approaches to Forensic Archaeology: Topics Discussed during the European Meetings on Forensic Archaeology (EMFA)*. Springer, Cham, pp 77-91.
- MÁRQUEZ-GRANT N, FIBIGER L (eds) (2011) *The Routledge Handbook of Archaeological Human Remains and Legislation: An International Guide to Laws and Practice in the Excavation and Treatment of Archaeological Human Remains*. Routledge, Abingdon.
- MÁRQUEZ-GRANT N, ROBERTS, J (2012) *Forensic Ecology Handbook: From Crime Scene to Court*. John Wiley & Sons, Chichester.
- MÁRQUEZ-GRANT N, WEBSTER H, TRUESDELL J, FIBIGER L (2016) Physical anthropology and osteoarchaeology in Europe: history, current trends and challenges. *Int J Osteoarchaeol*, 26: 1078-1088.
- MÁRQUEZ-GRANT N, ERRICKSON D (2017) Ethical considerations: an added dimension. In: Errickson D, Thompson T (eds). *Human Remains: Another Dimension. The Application of 3D Imaging in the Funerary Context*. Academic Press, London, pp 193-201.
- MÁRQUEZ-GRANT N, PASSALACQUA NV, PILLOUD MA, LESTER N, DECKER S, FORD J (2019) Ethical concerns in forensic anthropology. In: Squires K, Errickson D, Márquez-Grant N (eds). *Ethical Approaches to Human Remains: A Global Challenge in Bioarchaeology and Forensic Anthropology*. Springer, Cham, pp 347-366.
- MACKINNON G, MUNDORFF AZ (2006). The World Trade Center – September 11th 2001. In: Thompson T, Black S (eds). *Forensic Human Identification: An Introduction*. CRC Press, Boca Raton FL, pp 485-499.
- MLADINA V (2016) Psychosocial aspects of interviewing and self-care for practitioners. In: Congram D (ed). *Missing Persons: Multidisciplinary Perspectives on the Disappeared*. Canadian Scholars' Press Inc, Toronto, pp 171-183.
- MOHD NOOR MS. SEE KHOO L, ZAMALIANA ALIAS WZ, HAZAM HASMIC A, ZAINI IBRAHIM M, MAHMOOD MS (2017) The clandestine multiple graves in Malaysia: the first mass identification operation of human skeletal remains. *Forensic Sci Int*, 278: 410.e1-410.e9.
- MOON C (2016) Human rights, human remains: forensic humanitarianism and the human rights of the dead. *Int Soc Sci J*, 65: 49-63.
- MUNDORFF AZ (2008) Anthropologist-directed triage: three distinct mass fatality events involving fragmentation of human remains. In: Adams BJ, Byrd JE (eds). *Recovery, Analysis, and Identification of Commingled Human Remains*. Humana Press, Totowa NJ, pp 123-144.
- MUNDORFF AZ (2009) Human identification following the World Trade Center Disaster: assessing management practices for highly fragmented and commingled remains [doctoral thesis]. Barnaby BC, Simon Fraser University.
- MUNDORFF AZ (2012) Integrating forensic anthropology into disaster victim identification. *Forensic Sci Med Pathol*, 8: 131-139.
- MUNDORFF AZ, SHALER R, BIESCHKE E, MAR-CASH E (2014) Marrying anthropology and DNA: essential for solving complex commingling problems in cases of extreme fragmentation. In: Adams BJ, Byrd JE (eds). *Commingled Human Remains: Methods in Recovery, Analysis, and Identification*. Academic Press, San Diego CA, pp 257-273.
- NAKHAEIZADEH S, DROR IE, MORGAN RM (2014) Cognitive bias in forensic anthropology: visual assessment of skeletal remains is susceptible to confirmation bias. *Sci Justice*, 54: 208-214.
- NANNETTI A (2020) How might false positives and false negatives in bone recognition be reduced in disaster recovery by specialist search and recovery officers? [BSc Dissertation]. Winchester, University of Winchester.
- OBERTOVA Z, ADALIAN P, BACCINO E, CUNHA E, DE BOER HH, FRACASSO T, KRANIOTI E, LEFEBVRE P, LYNNERUP N, ANJA PETAROS A, ROSS A, STEYN M, CATTANEO C (2019) The status of forensic anthropology in Europe and South Africa: results of the 2016 FASE questionnaire on forensic anthropology. *J Forensic Sci*, 64: 1017-1025.
- OLIVIERI L, MAZZARELLI D, BERTOGLIO B, DE ANGELIS D, PREVIDERÈ C, GRIGNANI P, CAPPELLA A, PRESCIUTTINI S, BERTUGLIA C, DI SIMONE P, POLIZZI N, IADICICCO A, PISCITELLI V, CATTANEO C (2018) Challenges in the identification of dead migrants in the Mediterranean: The case study of the Lampedusa shipwreck of October 3rd 2013. *Forensic Sci Int*, 285: 121-128.
- PARRA RC, ZAPICO SC, UBELAKER DH (eds) (2020) *Forensic Science and Humanitarian Action: Interacting with the Dead and the Living*. John Wiley & Sons, Chichester.
- PASSALACQUA NV, PILLOUD MA (2018) *Ethics and Professionalism in Forensic Anthropology*. Academic Press, London.
- PARK DK, PARK KH, KO JS, KIM YS, CHUNG NE, AHN YW, HAN SH (2009) The role of forensic anthropology in the examination of the Daegu Subway Disaster (2003, Korea). *J Forensic Sci*, 54: 513-518.
- POKINES JT, SYMES SA (eds) (2013) *Manual of Forensic Taphonomy*. CRC Press, Boca Raton FL.
- PRIETO JL, TORTOSA C, BEDATE A, SEGURA L, ABENZA JM, MARISCAL DE GANTE MC, CONEJERO J, MAGAÑA, PEREA B (2007) The 11 March 2004 Madrid terrorist attacks: the importance of the

- mortuary organisation for identification of victims. A critical review. *Int J Legal Med*, 121: 517-522.
- QUATREHOMME G, TOUPENAY S, DELABARDE T, PADOVANI B, ALUNNI V (2019) Forensic answers to the 14th of July 2016 terrorist attack in Nice. *Int J Legal Med*, 133: 277-287.
- RAINWATER CW, CROWDER C, HARTNETT KM, FRIDI JS, FIGURA BJ, GODBOLD J, WARNASCH SC, ADAMS BJ (2012) Forensic anthropology at the New York City Office of Chief Medical Examiner. In: Dirkmaat D (ed). *A Companion to Forensic Anthropology*. Wiley-Blackwell, Chichester, pp 549-566.
- RITTER N (2007) Identifying remains: lessons learned from 9/11. *N J Journal*, 256: 20-26.
- ROBERTS J, MÁRQUEZ-GRANT N (2012) Forensic anthropology. In: Márquez Grant N, Roberts J (eds). *Forensic Ecology Handbook: From Crime Scene to Court*. Wiley-Blackwell, Chichester, pp 49-67.
- ROSEN L (1977) The anthropologist as expert witness. *Am Anthropol*, 79: 555-578.
- ROSS AH, CUNHA E (eds) (2019) *Dismemberments: Perspectives in Forensic Anthropology and Legal Medicine*. Academic Press, London.
- ROSS AH, LANFEAR AK, MAXWELL AB (2016) Establishing standards for side-by-side radiographic comparisons. *Am J Foren Med Path*, 37: 86-94.
- RUTTY GN, BIGGS MJP, BROUGH A, MORGAN B, WEBSTER P, HEATHCOTE A, DOLAN J, ROBINSON C (2020) Remote post-mortem radiology reporting in disaster victim identification: experience gained in the 2017 Grenfell Tower disaster. *Int J Legal Med*, 134: 637-643.
- SAUL F, SAUL J (2003) Planes, trains, and fireworks: the evolving role of the forensic anthropologist in mass fatality incidents. In: Steadman DW (ed). *Hard Evidence: Case Studies in Forensic Anthropology*. Prentice Hall, Upper Saddle River NJ, pp 266-277.
- SCHMELING A, GRUNDMANN C, FUHRMANN A, KAATSCH HJ, KNELL B, RAMSTHALER F, REISINGER W, RIEPERT T, RITZ-TIMME S, RÖSING FW, RÖTZSCHER K, GESERICK G (2008) Criteria for age estimation in living individuals. *Int J Legal Med*, 122: 457-460.
- SCHMITT S, SOZER A, FOWLER G, MAZOORI D (2015) Physicians for human rights. In: Groen WM, Márquez-Grant N, Janway RC (eds). *Forensic Archaeology: A Global Perspective*. Wiley-Blackwell, Chichester, pp 471-478.
- SEE KL, AZIZ S, MAHMOOD MS (2016) Beyond DVI: future identification, research and archiving. *J Forensic Res*, 7: doi: 10.4172/2157-7145.1000359.
- SCHMIDT CW, SYMES SA (eds) (2015) *The Analysis of Burned Human Remains*. 2nd ed. Academic Press, London.
- SCHOTSMANS EMJ, MÁRQUEZ-GRANT N, FORBES SL (eds) (2017) *Taphonomy of Human Remains: Forensic Analysis of the Dead and the Depositional Environment*. John Wiley & Sons, Chichester.
- SLEDZIK P, MUNDORFF AZ (2016) Forensic anthropology in disaster response. In: Blau S, Ubelaker DH (eds). *Handbook of Forensic Archaeology and Anthropology*. 2nd ed. Routledge, Abingdon, pp 477-495.
- STEADMAN DW, ADAMS BJ, KONGSBERG LW (2006) Statistical basis for positive identification in forensic anthropology. *Am J Phys Anthropol*, 131: 15-26.
- TERSIGNI-TARRANT MTA, LANGLEY NR (2017) Forensic anthropology in the United States: past and present. In: Langley NR, Tersigni-Tarrant MTA (eds). *Forensic Anthropology: A Comprehensive Introduction*. CRC Press, Boca Raton FL, pp 3-22.
- THOMPSON T (2001) Legal and ethical considerations of forensic anthropological research. *Sci Justice*, 41: 261-270.
- TIDBALL-BINZ M (2007) Managing the dead in catastrophes: guiding principles and practical recommendations for first responders. *Int Review Red Cross*, 89: 421-442.
- TRIGGER D, MARTIN D, MEMMOTT P, WINN P, BURKE P, PETERSON N, PALMER K (2013) Forensic social anthropology. In: Freckelton IR, Selby H (eds). *Expert Evidence: Law, Practice, Procedure and Advocacy*. 5th Ed. Thomson Reuters (Scientific) Inc. & Affiliates, Pyrmont NSW, pp 36.51-36.9058.
- TURNER AC (1992) Prolegomenon to a forensic cultural anthropology. *Am J Trial Advoc*, 16: 391-415.
- UBELAKER DH (ed) (2015) *The Global Practice of Forensic Science*. Wiley-Blackwell, Chichester.
- UBELAKER DH (2018) A history of forensic anthropology. *Am J Phys Anthropol*, 165: 915-923.
- UBELAKER DH, OWSLEY DW, HOUCK MM, CRAIG E, GRANT W, WOLTANSKI T, FRAM R, SANDNESS K, PEERWANI N (1995) The role of forensic anthropology in the recovery and analysis of Branch Davidian Compound victims: recovery procedures and characteristics of the victims. *J Forensic Sci*, 40: 335-340.
- UBELAKER DH, SHAMLOU A, KUNKLE A (2019a) Contributions of forensic anthropology to positive scientific identification: a critical review. *Forensic Sci Res*, 4: 45-50.
- UBELAKER DH, SHAMLOU A, KUNKLE AE (2019b) Forensic anthropology in the global investigation of humanitarian and human rights abuse: Perspective from the published record. *Sci Justice*, 59: 203-209.
- WADEL (2016) How forensic anthropologists are helping the families of Mexico's disappeared seek justice. Science. 14 December. <https://www.sciencemag.org/news/2016/12/how-forensic-anthropologists-are-helping-families-mexicos-disappeared-seek-justice> [Accessed 29.07.2018].
- WAGNER S (2014) The social complexities of human remains. In: Adams BJ, Byrd J (eds). *Commingled Human Remains: Methods in Recovery, Analysis, and Identification*. Academic Press, London, pp 491-506.
- WALSH-HANNEY H, LIEBERMAN LS (2005) Ethical concerns in forensic anthropology. In: Turner TR (ed). *Biological Repatriation and Ethics: From Repatriation to Genetic Identity*. State University of New York Press, New York, pp 121-132.
- WATHERSTON J, MCNEVIN D, GAHAN ME, BRUCE B, WARD J (2018) Current and emerging tools for the recovery of genetic information from post-mortem samples: New directions for disaster victim identification. *Forensic Sci Int: Genetics*, 37: 270-282.
- WINSKOG C (2012) Underwater disaster victim identification: the process and the problems. *Forensic Sci Med Pathol*, 8: 174-178.
- WIRSEMA J, WOODY A (2016) The forensic anthropologist in the mass fatality context. *Acad Forensic Pathol*, 6: 455-462.
- ZIĘTKIEWICZ E, WITT M, DACA P, ŻEBRACKA-GALA J, GONIEWICZ M, JARZĄB B, WITT M (2012) Current genetic methodologies in the identification of disaster victims and in forensic analysis. *J Appl Genet*, 53: 41-60.