CHAPTER 1

New directions in forensic anthropology

Douglas H. Ubelaker
Smithsonian Institution, Department of Anthropology, National Museum of Natural History,Washington, DC, USA

1.1 Introduction

Forensic anthropology represents the application of knowledge and methodology within anthropology to medicolegal issues. This process usually involves the detection, recovery, and analysis of materials that were thought to represent human skeletal remains. Analysis focuses on determining if the materials are in fact human remains, and if so, gleaning information about the individual they represent. Central goals in this effort are aimed at personal positive identification and detection of foul play.

Academic roots of the field extend back into nineteenth century European centers of anatomy and medicine. Advances in comparative anatomy, anthropometry, and growth and development by such pioneers as Paul Broca (1824–1880), Alphonse Bertillon (1853–1914), and Johann Friedrich Blumenbach (1752–1840) laid the European foundation for later advances. In the United States, two high-profile trials, the Parkman murder trial relating to a death at Harvard University in Massachusetts and the Chicago-based Adolph Luetgert trial brought widespread attention to the nascent field of forensic anthropology. These legal events involved testimony by Harvard professors Oliver Wendell Homes (1809–1894) and Jefferies Wyman (1814–1874) and the Chicago-based anthropologist George A. Dorsey (1868–1931). Research specifically targeting problems in forensic anthropology was initiated by the pioneers Thomas Dwight

The Future of Forensic Science, First Edition. Edited by Daniel A. Martell.

(1843–1911), H.H. Wilder (1864–1928), Paul Stevenson (1890–1971), Earnest A. Hooton (1887–1954), T. Wingate Todd (1885–1938), and Smithsonian anthropologist Aleš Hrdlička (1869–1943) among others. The modern era with a specific focus on forensic anthropology as an academic area of anthropology and forensic science was ushered in by Wilton M. Krogman (1903–1987) and T. D. Stewart (1901–1997) with key contributions also by Mildred Trotter (1899–1991). Organizational advances included the 1972 effort to form a new section of the American Academy of Forensic Sciences and the 1977/1978 establishment of the American Board of Forensic Anthropology, largely through the leadership of past AAFS President Ellis R. Kerley (1924–1998). Clyde C. Snow (1928–2014) became involved in identification efforts in Latin America in 1984 and advanced global anthropological involvement in humanitarian and human rights investigations relating to anthropology. These pioneers and early initiatives coupled with abundant published research and casework established the foundation of the current field of forensic anthropology.

Although contemporary forensic anthropology is generally regarded as a subdiscipline within the more general areas of forensic science and anthropology, it really involves a conglomerate of applications and methodologies that are problem-specific. These areas of application include detection, recovery, determination of human status, estimation of age at death, time since death, sex, ancestry and living stature, assessment of postmortem history, positive identification, and evaluation of evidence for foul play. Each of the major areas of application within forensic anthropology presents its own methodology, individual historical development, and research issues (Steadman 2013). Collectively, they also require broad training and experience that is usually captured in various ways in the skills of individual practitioners.

This chapter examines methodological issues within each of the areas of application. Current techniques and developments are noted. However, since the nature of forensic anthropology and its applications are rapidly evolving, emerging issues and likely future solutions are emphasized (Lesciotto 2015).

1.2 Detection and recovery

Many cases within the field of forensic anthropology begin with efforts to detect the presence of human remains. Roots of these efforts usually stem from investigative information regarding past events suggesting the possible or likely presence of human remains. Although the nature of such cases is highly variable, a classic scenario would involve an informant indicating he witnessed a past homicide and providing general details regarding the location of burial of the decedent. The anthropologist might serve as a team consultant/participant to assist in organizing the search and advising on what methodological approaches might be utilized. If a specific location is found or targeted, the anthropologist should organize or conduct the excavation or particular detection effort. In such scenarios, it is important that the anthropologist participate in the detection effort to immediately recognize the presence of human remains if encountered.

As with most areas of application in forensic anthropology, the selection of search and detection methods depends on the issues presented by the particular case (Cheetham and Hanson 2009). The size of the search area, quality of the investigative information, topography and nature of the terrain, and availability of supportive equipment and personnel represent key variables. Possible approaches include pedestrian survey, aerial survey, and the use of cadaver dogs (Holland and Connell 2009). Land surface searches usually seek physical evidence (human remains, clothing, other artifacts, etc.) or evidence of past soil disturbance that might indicate human burial. Past soil disturbance may present detectable variation in the normal topography. Significant variants may include depressions, mounds, or unusual vegetation patterns.

In recent years, traditional survey techniques have been supplemented with technological advancement. Examples include ground-penetrating radar, soil resistivity, and magnetometry. Each of these applications seeks variations in soil patterns that might represent the soil disturbance associated with human burial. They are ideally utilized in homogeneous environments with minimal soil disturbance.

Once a specific site of possible human burial has been located, detailed excavation is called for. The forensic anthropologist trained in archeological techniques is uniquely qualified to conduct this work. The goal is to define the limits of the original burial and locate, document, and recover all relevant evidence, especially human remains and associated artifacts. Proper excavation is needed to minimize damage to the evidence and to document patterns and associations. Such work, conducted properly, maximizes the potential of later interpretation.

The nature of search and recovery efforts varies tremendously with the issues presented by each case. Although the approaches discussed previously are generally relevant, specific applications must target the individuality of the case. Scenes can vary from the classic human burial described previously to underwater environments, the aftermath of building fires, natural disasters, political conflicts, airplane crashes, and others.

Although technological advances in this area of forensic anthropology have been both impressive and useful, in my view, the primary advancement has been (and will continue to be) the growing inclusion of anthropologists in search and recovery efforts. Leadership in search and recovery teams increasingly understands the value of including the skilled anthropologist when human remains may be anticipated.

1.3 Determination of human status

A primary step in forensic anthropological analysis of recovered materials consists of determining if human remains are present. If intact bones or teeth are detected, then this task is easily accomplished through morphological examination (Mulhern 2009). However, in many cases, evidence is fragmentary and/or has been compromised by thermal events, trauma, antemortem disease, or other factors making morphological assessment difficult. In many forensic evidence situations such as recovered fire debris, it can be difficult to distinguish fragments of bone and tooth from other materials. Recent technological advances have greatly augmented anthropological capability to accurately evaluate such evidence.

Techniques of scanning electron microscopy/energy dispersive spectroscopy (SEM/EDS) are especially useful to separate fragments of bone and tooth from other similarly appearing materials. Bones and teeth contain proportions of calcium and phosphorus that differ from other materials commonly recovered in scenes (Zimmerman et al. 2015). Comparative databases have been established for the composition of these materials enabling a definitive diagnosis for the presence of bone or tooth following SEM/EDS analysis (Ubelaker et al. 2002). However, since humans and other animals share chemical composition of their bones and teeth, this approach will not lead to species determination.

To determine species represented by bone or tooth, a variety of approaches are available. Histological examination may reveal features (plexiform bone or osteon-banding patterns) that are not present in humans. However, the human histological pattern is shared with many nonhuman animals usually precluding definitive diagnosis of human status.

Molecular analysis of bone or tooth samples may reveal the species represented. This approach utilizing mitochondrial DNA markers has been employed successfully in wildlife forensic science, especially related to game and commercial species of legal interest (Guglich et al. 1994).

In my view, an ideal technique in such cases consists of solid-phase double-antibody protein radioimmunoassay (pRIA). This technique involves the extraction of protein from very small samples of the unknown specimen. The protein is then exposed in a two-phase process to species-specific antibodies. The extent of the species-specific antibody reaction can be measured through an associated radioactive marker. The technique can not only determine if human remains are present but also the likely nonhuman species present. The amount of sample required for the analysis is so small, that enough remains for molecular analysis if the pRIA analysis determines that human species is present (Ubelaker et al. 2004).

Future progress in this area of forensic anthropology likely will involve making this technology more economical and mobile. Great advancement would be made if those working in scene recovery could immediately determine the species status of recovered fragments.

1.4 Age at death

In the analysis of human skeletal remains, forensic anthropologists attempt to create a biological profile of the individual represented in order to facilitate the search for identification (Rogers 2009). Accurate estimation of the age at death is an essential component of this process. Age at death usually represents a known feature of missing persons and is thus an important element of any attempt at identification. Methodology utilized to estimate age at death varies depending upon the aspects of the remains present and the general age of the individual. For fetal remains, long bone lengths can be used to estimate body length and age using published regression equations. For infants, children, and adolescents, bone size and maturation provide some information, but the most reliable estimates are derived from evaluations of dental formation.

In recent years, the process of evaluating age at death has progressed through the acquisition of new methods, critical evaluation of existing methods, and greater awareness of the impact of population variation (Merritt 2014; Wink 2014; De Angelis et al. 2015). New methodology continues to explore not only areas of the skeleton exhibiting age-related change, but also existing techniques in other areas of science show promise in forensic application (Mays 2014; Boyd et al. 2015). An example of the latter consists of quantification of mtDNA mutations. Such mutations have been documented as playing an important role in human aging but only recently have been considered for their forensic applications (Zapico and Ubelaker 2013a).

Critical evaluation of methodology represents an essential ingredient in quality forensic science. In anthropology, it is especially important to test established methods in regard to new applications and in consideration of likely population variation (Moraitis et al. 2014; Shirley and Ramirez Montes 2015). Assessment of the impact of population variation in age at death estimation is facilitated by the increasing availability of documented skeletal collections in different global regions (Ubelaker 2014a). Many such studies document that population variation does exist in the process of human aging. This research suggests that population-specific standards should be employed when available.

Future research in age at death estimation likely will focus on the issues discussed previously. Goals include acquisition of data and samples more adequately reflecting global population variation. Such data probably will emerge from studies of newly assembled documented skeletal collections as well as increasing research on the living. Investigators will also concentrate on more robust quantification of the probabilities involved in age estimation (Villa et al. 2015). Accurate statistical presentations are needed to more realistically convey the associated variation and to satisfy increasing scrutiny in the legal arena.

1.5 Time since death

When human remains are found, authorities need to know as accurately as possible the date of death. Unfortunately, when remains are skeletonized, research and casework have demonstrated the difficulty of accurate estimation from morphology due to the myriad of variables involved. Climate, seasonality, soil conditions, individual constitution, mortuary treatment, ground water levels, extent and type of clothing and containers, accessibility to insects and scavengers, and many other factors can dramatically affect the extent of tissue preservation (Forbes and Nugent 2009; Kanz et al. 2014). In short, when remains are skeletonized and information is lacking of these variables, it is not possible to produce an accurate estimate from observations of tissue preservation. Considerable perspective has been acquired through experimentation and observations at various decay facilities, especially in consideration of local environmental issues and degree days of exposure (Dabbs 2015; Roberts and Dabbs 2015). Nevertheless, if remains are skeletonized or display environmentally induced unusual soft tissue preservation, morphology alone does not permit accurate estimates of time since death.

Radiocarbon analysis represents an attractive solution to this problem. Carbon-14 dating has long been utilized in archeological applications to securely date recovered samples. This application is based on the knowledge that the carbon-14 isotope is mildly radioactive with a known half-life of 5730 years. In the traditional application, the extent of decay is quantified and used to calculate the antiquity prior to the modern value of 1950 CE. If decay is detected, traditional analysis will reveal the great antiquity of the remains and usually exclude them from the need for medicolegal analysis.

If the remains are modern, both the birth date and death date potentially can be established through comparison of the modern radiocarbon values with the documented post-1950 bomb-curve of atmospheric levels. After 1950, the amount of base radiocarbon in the atmosphere and food chain increased dramatically until about 1965 due to atmospheric testing of thermal nuclear devices. While the levels have decreased since 1965, they continue to remain above those present prior to 1950. Thus, if the elevated levels are found, they indicate the organism was alive after 1950. Birth date and death date may be estimated from a comparison of the elevated levels with the bomb-curve, in consideration of the tissues sampled and the estimated age at death of the individual (Ubelaker et al. 2006; Ubelaker 2014b).

Future research likely will concentrate on the variables involved in radiocarbon analysis, especially the lag time (difference between atmospheric levels and those in human tissues) association with age of the individual and the variation presented in different skeletal and dental tissues. Attention also is needed on how other isotope markers of the period of modern bomb testing can be utilized to assess the death date.

1.6 Sex estimation

Since sex is almost always known in regard to characteristics of missing persons, it, like age at death, represents an important component of the biological profile. If the pelvis is available, in most cases, sex can be reliably estimated from adult skeletal morphology. Sex estimation is less reliable if the pelvis is absent or damaged since sexual dimorphism in other bones is size-related and presents some variation (Fateh et al. 2014; Michel et al. 2015). In general, sex estimation from bone morphology is not reliable in immature remains. Molecular analysis, particularly amelogenin testing, offers a reliable alternative to morphological assessment, even with immature remains (Baker 2009).

Considerable research has been conducted on sexual variation in the morphology of many individual bones of the skeleton (Wescott 2015). Such information is important since in many cases, skeletons are incomplete and may even consist of individual bones (Ostrofsky and Churchill 2015).

Research also has established considerable population variation in the expression of sexual dimorphism in the human skeleton (Brzobohatá et al. 2015). Studies originating from global samples of documented human remains gradually have made available population-specific data on sex differences (Spradley et al. 2015). As with other applications in forensic anthropology, sex estimation from bone morphology should employ local standards (Amores et al. 2014).

Future work is needed to further clarify population variation regarding sex differences in various aspects of the human skeleton. Research is also needed for additional clarification of the probabilities involved. Investigations also may discover sex differences in other tissues and substances within preserved human remains that might prove useful (Zapico and Ubelaker 2013b).

1.7 Ancestry

Evaluation of ancestry represents one of the most challenging applications of forensic anthropology (Hefner and Ousley 2014). Methodology involves both metric and nonmetric approaches and has advanced with the formation of new databases and useful customized regression formulae (Sauer and Wankmiller 2009; Pilloud et al. 2014; Klales and Kenyhercz 2015).

An important advancement has been the recognition that community ancestry classifications relate social/historical issues, as well as biological factors. Future progress likely will involve enhanced regional databases but will continue to respect the social dimensions involved.

1.8 Living stature

Current methods to estimate living stature in adults involve applications of sex and ancestry-specific regression equations to individual bones or groups of bones and also, in cases involving complete skeletons, measuring those bones that contribute to living stature (Willey 2009). Research has demonstrated the greater accuracy of the latter approach, but it is limited by frequently encountered incomplete remains. Since body proportions are known to vary considerably between the sexes and in different populations, formulae are sex and population-specific. Increasing global availability of skeletons from individuals of documented living stature has facilitated the formulation of new population-specific formulae. Also, important has been the increased recognition of the likely errors involved in the estimated statures of missing persons.

Progress in stature estimations likely will occur in (i) the availability of new formulae for different bones from more populations and (ii) more nuanced use of "known" statures from missing persons.

1.9 Postmortem history

In the forensic context, taphonomy represents the study of factors contributing to postmortem alterations of human remains (Nawrocki 2009). This area of forensic investigation recognizes that postmortem change can be influenced by many different factors. Although these influences complicate the estimation of time since death, details may reveal useful indicators of postmortem events. Animal gnaw marks, evidence of sun exposure, vegetation residue, adhering soil particles, associated arthropod remains as well as tool marks all may provide critical evidence needed to interpret the postmortem history of human remains (Young et al. 2015).

The field of taphonomy has attracted considerable research attention, leading to a growing scientific literature. Research includes a variety of innovative experiments providing a greater understanding of the impact of environmental agents on the postmortem condition of human remains.

1.10 Positive identification

Much of the forensic investigation summarized is directed toward the goal of positive individual identification. Usually, this process involves comparing the discovered individual attributes of recovered human remains with those of missing persons. Once the search is narrowed, possibly relating the remains to a few missing persons with the necessary shared characteristics, detailed analysis is conducted to ascertain if an identification can be made. Positive identification requires that unique features are found to be shared between the recovered remains and a particular missing person. In the practice of forensic anthropology, this evidence usually originates from radiographs or related medical images of bone structure.

Proper identification is a two-step procedure. First, features must be found that are shared between the recovered remains and a missing person. The second step must explain any differences that occur and assess the uniqueness of the shared attributes. Positive identification results when differences can be successfully reconciled and the shared features are judged to be collectively unique.

Progress in the identification process consists of growing awareness of the probabilities involved in making such assessments. Positive identification must be distinguished from putative, tentative, or possible identifications. Key to this distinction is assessment of the uniqueness of the features examined and the high bar required for positive identification (Stephan and Guyomarc'h 2015). Thoughtful research has contributed to realistic assessment of these issues, especially in radiographic analysis. Interpretation is influenced not only by the uniqueness of skeletal attributes but also by the highly variable quality of the images available for comparison, especially antemortem images of the once living individual.

Future progress in this area likely will focus on new studies of variation of the skeletal structures mostly commonly encountered in the positive identification process (Maxwell and Ross 2014; Stephan et al. 2014; Derrick et al. 2015). Automation and more rigorous statistical procedures will also likely impact procedures in positive ways (Lee et al. 2015; Stephan 2015).

1.11 Foul play

Forensic anthropologists routinely make unique contributions to evaluations of foul play involving skeletal remains. Although determination of cause and manner of death is a responsibility of forensic pathologists, anthropologists frequently present key evidence that contributes to such determinations (Fleischman 2015). Once alterations are detected, analysis must determine if they represent antemortem conditions that likely were not related to the death event, postmortem, and taphonomic processes or those that may be related to the death event (Cunha and Pinheiro 2009). Those possibly related to the death event are frequently described as being perimortem, indicating they were produced at or around the time of death (Loe 2009).

Considerable advancement has been sustained in this area through enhanced assessment of taphonomic factors (as previously outlined), better understanding of the evidence for bone remodeling suggestive of the antemortem condition, and studies of skeletal trauma (Rickman and Smith 2014; Beck et al. 2015). The trauma studies include more nuanced understanding of the bone fracture process and how the type of trauma can be determined from skeletal alterations (Love et al. 2015; Pinto et al. 2015; Wiersema et al. 2015). Also important are studies to help determine if fractures and evidence of various types of injury were sustained in the perimortem window or postmortem (Cappella et al. 2014; Báez-Molgado et al. 2015).

Experimental research likely will fuel future progress in this area. More knowledge is needed regarding additional factors that produce bone alterations and the impact of such postmortem conditions as thermal change, exposure to different environments and different rates and types of taphonomic processes (Dussault et al. 2014; Smith 2014; Robbins et al. 2015).

1.12 Certification

As in other areas of forensic science, individual certification represents an important issue. With growing numbers of professionals in the general field of anthropology attracted to forensic applications, it is important to reinforce standards of qualification. In North America, the American Board of Forensic Anthropology has offered certification to qualified anthropologists since 1977. Currently, certification is not limited to residents of North America but requires a doctorate degree relating to forensic anthropology and three years of experience in the field following receipt of the degree. Qualified applicants must also pass an examination administered by the ABFA. Since 1977, 111 individuals have been certified and 77 remain active in 2015.

Certification in forensic anthropology is also available in Latin America through the Asociación Latinoamericana de Antropología Forense. Qualified individuals also must pass an examination.

The United Kingdom offers certification in forensic anthropology through the Royal Anthropological Institute. The UK certification program recognizes three levels of expertise. Certification also is available through the Forensic Anthropology Society of Europe, a section of the International Academy of Legal Medicine. The FASE system recognizes two levels of expertise and also awards Honoris Causa certification to very experienced and established practitioners.

The certification programs previously described attempt in varying ways to credential qualified colleagues and provide the legal system some assurance that involved forensic anthropologists have the necessary skills and experience. These programs address the dual challenges of attempting to maintain high standards yet also recognize the highly variable backgrounds of those currently practicing in the field.

1.13 Conclusion

Forensic anthropology represents a robust and rapidly evolving field that embraces new research and experimentation. Central issues in the future likely will involve establishing probabilities associated with the many techniques utilized, expanded certification programs, laboratory accreditation, better understanding the varied impacts of global variation, and new applications.

Forensic anthropology continues to attract highly qualified students and professionals. They are welcome since they bring fresh perspective, new research ideas, and provide the numbers needed to address rapidly expanding applications. As with other areas of forensic science, forensic anthropology offers those involved an opportunity to use science to address key issues in contemporary society. These applications are likely to become more robust due to the high quality of new students entering this field.

Acknowledgments

The author would like to thank Madeleine Rosenstein of the George Washington University and Cassandra DeGaglia of the Smithsonian Institution for their assistance in the preparation of bibliographic materials.

References

Amores, A., Botella, M., and Alemán, I. (2014). Sexual dimorphism in the 7th cervical and 12th thoracic vertebrae from a Mediterranean population. *Journal of Forensic Sciences* 59 (2): 301–305.

Báez-Molgado, S., Bartelink, E., Jellema, L. et al. (2015). Classification of pelvic ring fractures in skeletonized human remains. *Journal of Forensic Sciences* 60 (S1): S171–S176.

Baker, L. (2009). Biomolecular applications. In: *Handbook of Forensic Anthropology and Archaeology* (ed. S. Blau and D.H. Ubelaker), 322–334. Walnut Creek, CA: Left Coast Press, Inc.

Beck, J., Ostericher, I., Sollish, G., and De Léon, J. (2015). Animal scavenging and scattering and the implications for documenting the deaths of undocumented border crossers in the Sonoran Desert. *Journal of Forensic Sciences* 60 (S1): S11–S20.

Boyd, K., Villa, C., and Lynnerup, N. (2015). The use of CT scans in estimating age at death by examining the extent of ectocranial suture closure. *Journal of Forensic Sciences* 60 (2): 363–369.

Brzobohatá, H., Krajíček, V., Horák, Z., and Velemínská, J. (2015). Sex classification using the three-dimensional tibia form or shape including population specificity approach. *Journal of Forensic Sciences* 60 (1): 29–40.

Cappella, A., Amadasi, A., Castoldi, E. et al. (2014). The difficult task of assessing perimortem and postmortem fractures on the skeleton: a blind text on 210 fractures of known origin. *Journal of Forensic Sciences* 59 (6): 1598–1601.

Cheetham, P.N. and Hanson, I. (2009). Excavation and recovery in forensic archaeological investigations. In: *Handbook of Forensic Anthropology and Archaeology* (ed. S. Blau and D.H. Ubelaker), 141–149. Walnut Creek, CA: Left Coast Press, Inc.

Cunha, E. and Pinheiro, J. (2009). Antemortem trauma. In: *Handbook of Forensic Anthropology and Archaeology* (ed. S. Blau and D.H. Ubelaker), 246–262. Walnut Creek, CA: Left Coast Press, Inc.

Dabbs, G.R. (2015). How should forensic anthropologists correct national weather service temperature data for use in estimating the postmortem interval? *Journal of Forensic Sciences* 60 (3): 581–587.

De Angelis, D., Mele, E., Gibelli, D. et al. (2015). The applicability of the Lamendin method to skeletal remains buried for a 16-year period: a cautionary note. *Journal of Forensic Sciences* 60 (S1): S177–S181.
Derrick, S.M., Raxter, M.H., Hipp, J.A. et al. (2015). Development of computer-assisted forensic radiographic identification method using the lateral cervical and lumbar spine. *Journal of Forensic Sciences* 60 (1): 5–12.
Dussault, M.C., Smith, M., and Osselton, D. (2014). Blast injury and the human skeleton: an important emerging aspect of conflict-related trauma. *Journal of Forensic Sciences* 59 (3): 606–612.
Fateh, E.E.A., Shirley, N.R., Jantz, R.L., and Mahfouz, M.R. (2014). Improving sex estimation from crania using a novel three-dimensional quantitative method. *Journal of Forensic Sciences* 59 (3): 590–600.
Fleischman, J.M. (2015). Radiographic identification using midline medical sternotomy wires. *Journal of Forensic Sciences* 60 (S1): S3–S10.
Forbes, S. and Nugent, K. (2009). Dating of anthropological skeletal remains of forensic interest. In: *Handbook of Forensic Anthropology and Archaeology* (ed. S. Blau and D.H. Ubelaker), 164–173. Walnut Creek, CA: Left Coast Press, Inc.
Guglich, E.A., Wilson, P.J., and White, B.N. (1994). Forensic application of repetitive DNA markers to the species identification of animal tissues. *Journal of Forensic Sciences* 39 (2): 353–361.
Hefner, J.T. and Ousley, S.D. (2014). Statistical classification methods for estimating ancestry using morphoscopic traits. *Journal of Forensic Sciences* 59 (4): 883–890.
Holland, T.D. and Connell, S.V. (2009). The search for and detection of human remains. In: *Handbook of Forensic Anthropology and Archaeology* (ed. S. Blau and D.H. Ubelaker), 129–140. Walnut Creek, CA: Left Coast Press, Inc.
Kanz, F., Reiter, C., and Risser, D.U. (2014). Citrate content of bone for time since death estimation: results from burials with different physical characteristics and known PMI. *Journal of Forensic Sciences* 59 (3): 613–620.
Klales, A.R. and Kenyhercz, M.W. (2015). Morphological assessment of ancestry using cranial macromorphoscopics. *Journal of Forensic Sciences* 60 (1): 13–20.
Lee, W.J., Wilkinson, C.M., Hwang, H.S., and Lee, S.M. (2015). Correlation between average tissue depth data and quantitative accuracy of forensic craniofacial reconstructions measured by geometric surface comparison method. *Journal of Forensic Sciences* 60 (3): 572–580.
Lesciotto, K.M. (2015). The impact of Daubert on the admissibility of forensic anthropology expert testimony. *Journal of Forensic Sciences* 60 (3): 549–555.
Loe, L. (2009). Perimortem trauma. In: *Handbook of Forensic Anthropology and Archaeology* (ed. S. Blau and D.H. Ubelaker), 263–283. Walnut Creek, CA: Left Coast Press, Inc.
Love, J.C., Derrick, S.M., Wiersema, J.M., and Peters, C. (2015). Microscopic saw mark analysis: an empirical approach. *Journal of Forensic Sciences* 60 (S1): S21–S26.

Maxwell, A.B. and Ross, A.H. (2014). A radiographic study on the utility of cranial vault outlines for positive identification. *Journal of Forensic Sciences* 59 (2): 314–318.

Mays, S. (2014). A test of recently devised method of estimating skeletal age at death using features of the adult acetabulum. *Journal of Forensic Sciences* 59 (1): 184–187.

Merritt, C.E. (2014). A test of Hartnett's revisions to the public symphysis and fourth rib methods on a modern sample. *Journal of Forensic Sciences* 59 (3): 703–711.

Michel, J., Paganelli, A., Varoquaux, A. et al. (2015). Determination of sex: interest of front sinus 3D reconstructions. *Journal of Forensic Sciences* 60 (2): 269–273.

Moraitis, K., Zorba, E., Eliopoulos, C., and Fox, S.C. (2014). A test of the revised auricular surface aging method on a modern European population. *Journal of Forensic Sciences* 59 (1): 188–194.

Mulhern, D.M. (2009). Differentiating human from nonhuman skeletal remains. In: *Handbook of Forensic Anthropology and Archaeology* (ed. S. Blau and D.H. Ubelaker), 153–163. Walnut Creek, CA: Left Coast Press, Inc.

Nawrocki, S.P. (2009). Forensic taphonomy. In: *Handbook of Forensic Anthropology and Archaeology* (ed. S. Blau and D.H. Ubelaker), 284–294. Walnut Creek, CA: Left Coast Press, Inc.

Ostrofsky, K.R. and Churchill, S.E. (2015). Sex determination by discriminant function analysis of lumbar vertebrae. *Journal of Forensic Sciences* 60 (1): 21–28.

Pilloud, M.A., Hefner, J.T., Hanihara, T., and Hayashi, A. (2014). The use of tooth crown measurements in the assessment of ancestry. *Journal of Forensic Sciences* 59 (6): 1493–1501.

Pinto, D.C., Love, J.C., Derrick, S.M. et al. (2015). A proposed scheme for classifying pediatric rib head fractures using case examples. *Journal of Forensic Sciences* 60 (1): 112–117.

Rickman, J.M. and Smith, M.J. (2014). Scanning electron microscope analysis of gunshot defects to bone: an underutilized source of information on ballistic trauma. *Journal of Forensic Sciences* 59 (6): 1473–1486.

Robbins, S.C., Fairgrieve, S.I., and Tracy, S.O. (2015). Interpreting the effects of burning on pre-incineration saw marks in bone. *Journal of Forensic Sciences* 60 (S1): S182–S187.

Roberts, L.G. and Dabbs, G.R. (2015). A taphonomic study exploring the differences in decomposition rate and manner between frozen and never frozen domestic pigs (*Sus scrofa*). *Journal of Forensic Sciences* 60 (3): 588–594.

Rogers, T.L. (2009). Skeletal age estimation. In: *Handbook of Forensic Anthropology and Archaeology* (ed. S. Blau and D.H. Ubelaker), 208–221. Walnut Creek, CA: Left Coast Press, Inc.

Sauer, N.J. and Wankmiller, J.W. (2009). The assessment of ancestry and the concept of race. In: *Handbook of Forensic Anthropology and Archaeology* (ed. S. Blau and D.H. Ubelaker), 187–200. Walnut Creek, CA: Left Coast Press, Inc.

Shirley, N.R. and Ramirez Montes, P.A. (2015). Age estimation in forensic anthropology: quantifications of observer error in phase versus component-based methods. *Journal of Forensic Sciences* 60 (1): 107–111.

Smith, A.C. (2014). The effects of sharp-force thoracic trauma on the rate and pattern of decomposition. *Journal of Forensic Sciences* 59 (2): 319–326.

Spradley, M.K., Anderson, B.E., and Tise, M.L. (2015). Postcranial sex estimation criteria for Mexican Hispanics. *Journal of Forensic Sciences* 60 (S1): S27–S31.

Steadman, D. (2013). The places we will go: paths forward in forensic anthropology. In: *Forensic Science: Current Issues, Future Directions* (ed. D.H. Ubelaker), 131–159. West Sussex: Wiley.

Stephan, C.N. (2015). Facial approximation – from facial reconstruction synonym to face prediction paradigm. *Journal of Forensic Sciences* 60 (3): 566–571.

Stephan, C.N. and Guyomarc'h, P. (2015). Qualification and perspective-induced shape change of clavicles at radiology and 3D scanning to assist human identification. *Journal of Forensic Sciences* 59 (2): 447–453.

Stephan, C.N., Amidan, B., Trease, H. et al. (2014). Morphometric comparison of clavicle outlines from 3D bone scans and 2D chest radiographs: a shortlisting tool to assist radiographic identification of human skeletons. *Journal of Forensic Sciences* 59 (2): 306–313.

Ubelaker, D.H. (2014a). Osteology reference collections. In: *Encyclopedia of Global Archaeology*, vol. 8 (ed. C. Smith), 5632–5641. New York, NY: Springer.

Ubelaker, D.H. (2014b). Radiocarbon analysis of human remains: a review of forensic application. *Journal of Forensic Sciences* 59 (6): 1466–1472.

Ubelaker, D.H., Ward, D.C., Braz, V.S., and Stewart, J. (2002). The use of SEM/EDS analysis to distinguish dental and osseous tissue from other materials. *Journal of Forensic Sciences* 47 (5): 940–943.

Ubelaker, D.H., Lowenstein, J.M., and Hood, D.G. (2004). Use of solid-phase double-antibody radioimmunoassay to identify species from small skeletal fragments. *Journal of Forensic Sciences* 49 (5): 924–929.

Ubelaker, D.H., Buchholz, B.A., and Stewart, J.E.B. (2006). Analysis of artificial radiocarbon in different skeletal and dental tissue types to evaluate date of death. *Journal of Forensic Sciences* 51 (3): 484–488.

Villa, C., Buckberry, J., Cattaneo, C. et al. (2015). Quantitative analysis of the morphological changes of the pubic symphyseal face and the auricular surface and implications for age at death estimation. *Journal of Forensic Sciences* 60 (3): 556–565.

Wescott, D.J. (2015). Sexual dimorphism in auricular surface projection and postauricular sulcus morphology. *Journal of Forensic Sciences* 60 (3): 679–685.

Wiersema, J.M., Derrick, S.M., Pinto, D.C. et al. (2015). Standardized descriptive method for the anthropological evaluation of pediatric skull fractures. *Journal of Forensic Sciences* 59 (6): 1487–1492.

Willey, P. (2009). Stature estimation. In: *Handbook of Forensic Anthropology and Archaeology* (ed. S. Blau and D.H. Ubelaker), 236–245. Walnut Creek, CA: Left Coast Press, Inc.

Wink, A.E. (2014). Pubic symphyseal age estimation from three-dimensional reconstructions of pelvic CT scans of live individuals. *Journal of Forensic Sciences* 59 (3): 696–702.

Young, A., Márquez-Grant, N., Stillman, R. et al. (2015). An investigation of red fox (*Vulpes vulpes*) and eurasian badger (*Meles meles*) scavenging, scattering, and removal of deer remains: forensic implications and applications. *Journal of Forensic Sciences* 60 (S1): S39–S55.

Zapico, S.C. and Ubelaker, D.H. (2013a). mtDNA mutations and their role in aging, diseases and forensic sciences. *Aging Diseases* 4 (6): 364–380.

Zapico, S.C. and Ubelaker, D.H. (2013b). Sex determination from dentin and pulp in a medicolegal context. *The Journal of the American Dental Association* 144 (12): 1379–1386.

Zimmerman, H.A., Schultz, J.J., and Sigmund, M.E. (2015). Preliminary validation of handheld X-ray fluorescence spectrometry: distinguishing osseous and dental tissue from nonbone material of similar chemical composition. *Journal of Forensic Sciences* 60 (2): 382–390.