This document sets forth background materials on the scientific research supporting examinations as conducted by the forensic laboratories at the Department of Justice. It also includes a discussion of significant policy matters. This document is provided to assist a public review and comment process of the related Proposed Uniform Language for Testimony and Reports (posted separately). It is not intended to, does not, and may not be relied upon to create any rights, substantive or procedural, enforceable by law by any party in any matter, civil or criminal, nor does it place any limitation on otherwise lawful investigative and litigative prerogatives of the Department.

SUPPORTING DOCUMENTATION FOR DEPARTMENT OF JUSTICE PROPOSED UNIFORM LANGUAGE FOR TESTIMON AND REPORTS FOR THE FORENSIC ANTHROPOLOGY DISCIPLINE

Background

Forensic anthropology is defined as the application of anthropological methods and theory – particularly those relating to the recovery and analysis of human remains – to resolve legal matters.

Anthropology is a broad field referring to the study of humans (from the Greek *anthropos* "man" and *logia* "study"). In the United States, it is typically considered to have four major sub-disciplines: linguistic anthropology, cultural anthropology, archaeology, and physical anthropology. Linguistic anthropology is the study of human communication, including differences in language across time and space, and how language systems affect human culture and behavior. Cultural anthropology (also called social anthropology or socio-cultural anthropology) is the study of human cultural variation, including social organization, politics, conflict, religion, etc. Archaeology is the study of human past through material remains such as artifacts and features. Physical anthropology is the study of the evolution and diversity of the human lineage, particularly human and non-human primate variation and behavior. Forensic anthropology is often considered an applied subfield of physical anthropology and sometimes of archaeology.

Principles of Forensic Anthropology Examinations

Given there are no absolute certainties in science, examiners need to provide scientific support for their conclusions. It is no longer sufficient for an examiner to state his or her opinion without also providing the scientific basis and clearly expressing the limitations associated with the science.

When conducting anthropology examinations, depending on the quality and quantity of evidentiary material present and the nature of the examination request, an examiner can determine whether material is skeletal (bone or tooth) versus some other material, and whether skeletal material is human or non-human in origin. For human skeletal material, certain biological parameters can be estimated including sex, age, ancestry and stature. Antemortem and postmortem skeletal material can be compared to determine whether they could have originated from the same source. Alterations to skeletal material can be assessed in regards to their timing in relation to the death event as well as the nature of the force that caused the alterations.

These assessments are based on scientific studies of bone chemistry, morphology and biology, along with well-established principles of skeletal biomechanics and studies of skeletal variation between groups (such as males and females, ancestral groups, and age groups). Many of these studies include rigorous statistical analyses and clearly-presented limitations as to what the analysis will support. The variety and complexity of factors that may affect the human skeleton often precludes definitive conclusions, and the results of anthropological examinations are therefore often conservatively presented, and include statistical support (including confidence intervals and error rates) where available and appropriate.

Examiners must clearly explain the definitions of their conclusions so as not to overstate or understate the weight of their conclusions. As such, examiners need to be aware of the limitations associated with opinion conclusions. When material is non-skeletal in origin, the examiner may not state the origin of the material, other than descriptive observations, or (in certain cases) the elemental constituents of the material. The examiner may not state the origin of non-human skeletal material (*i.e.*, species) beyond general categories (*e.g.*, large mammal, avian). The examiner may not state that the skeletal material could have originated from an individual with biological characteristics outside of the estimated parameters. The examiner may not state that antemortem or postmortem skeletal information must have originated from the same individual to the exclusion of all others. The examiner may not state that a particular implement was the source of a skeletal alteration, or state the cause or manner of death based on skeletal alterations and trauma.

By clearly expressing the scientific basis for the conclusion while remaining cognizant of the limitations, examiners will testify within the bounds of science.

Theory of Forensic Anthropology Examination

There is no single "theory" of forensic anthropology; it is based on principles developed in a wide array of scientific disciplines. Many of the techniques used in forensic anthropological examinations have their roots in anatomy, skeletal biology and physical anthropology, many of which are centuries old. A plethora of studies documenting skeletal variation in relation to sex, age, ancestry, individual variants, etc. has been published in anthropological, anatomical, and clinical literature, the vast majority of which have appeared in the *Journal of Forensic Sciences* and the *American Journal of Physical Anthropology*, but can also be found in *Forensic Science International*, the *International Journal of Osteoarchaeology*, *Medicine, Science and the Law*, the *International Journal of Legal Medicine*, the *Journal of Anatomy*, and the *Journal of Human Evolution* among others. Anthropological research and validation of examination techniques also appear in numerous texts and edited volumes including but not limited to *Forensic Anthropology: Current Methods and Practice* (Christensen et al., 2014), *Forensic Osteology: Advances in the Identification of Human Remains* (Reichs, 1998), *Forensic Anthropology: Contemporary Theory and Practice* (Komar and Buikstra, 2008), and *Forensic Taphonomy: The Postmortem Fate of Human Remains* (Haglund and Sorg, 1997). Several compendiums of anatomical reference material are also widely used and considered valid for casework including but not limited to *Gray's Anatomy* (Gray, 1858; Gray, 2008) and *Human Osteology* (White et al., 2011). Collectively, these works and others form the basis for performance of forensic anthropology examinations.

Forensic Anthropology Examination Processes

There are different methodologies and processes for conducting a forensic anthropology examination. The Department shares information regarding some appropriate processes below. The Department does not suggest that the processes outlined here are the only valid or appropriate processes.

Forensic anthropology examinations include various assessments and analyses of human skeletal remains (or potential human skeletal remains). Examinations include the determination of whether questioned evidentiary material from a potential death scene is skeletal (i.e., bone or tooth) in origin, and whether skeletal material is human in origin or from some other non-human animal. For human skeletal material, many cases involve unidentified remains for which anthropological examinations provide investigative information in the search for the individual's identity (including estimates of the individual's biological sex, ancestry, age and stature, as well as the assessment of skeletal variations that may narrow the search for identity such as previous injuries, pathologies, or developmental anomalies). In the event that a specific decedent is suspected, antemortem and postmortem skeletal information can be compared to determine whether they could have originated from the same person. Examinations may also include the assessment of skeletal trauma including the timing of alterations with respect to the death event, as well as the likely mechanism (i.e., the type of force, including blunt, sharp, projectile or thermal) of the trauma.

Forensic anthropological examinations are conducted on a variety of skeletal and suspected skeletal specimens. The determination of which approaches are used depends on the quality and quantity of material present, the needs of the examination, and the reliability and validity of available analytical methods.[1] Examinations may include visual (also called macroscopic), metric, microscopic (including histological), radiographic, or elemental analysis. Macroscopic examination involves the observation of the material with the naked eye, sometimes with directed lighting. In some cases such as photographic examinations and field assessments, visual examination may be the only method used; conclusions in these cases are typically very limited. Metric analysis involves taking and analyzing skeletal measurements (also called osteometrics) to assess their relationship with measurements from known population groups. This is typically accomplished by using calipers and osteometric boards (see Figure 1 below) to take a standard suite of well-documented skeletal measurements (*e.g.*, Moore-Jansen et al., 1994), although other 3D measurement approaches can also be used These measurements can be compared to those of known population groups using sophisticated metric analysis software. One widely-used metric analysis tool is Fordisc (Ousley and Jantz, 2005), a discriminant function statistical program that

[1] Anthropological examinations conducted by Department personnel are based on well-documented studies of human skeletal growth and development, individual and population-level variation, and principles of bone biomechanics. The variety and complexity of factors that may affect the human skeleton often precludes definitive conclusions, and the results of anthropological examinations are therefore often conservatively presented, and include statistical support (including confidence intervals and error rates) where available and appropriate.

calculates the probability of group membership based on measurements from known reference samples.

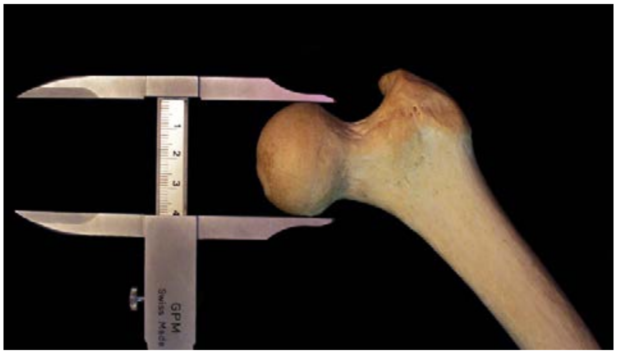

Figure 1: Sliding calipers used in skeletal metric analysis.
(from Christensen et al., 2014)

Radiographic analysis involves the use of high-energy radiation to examine and diagnose the internal structures of skeletal material (see Figure 2). This may include, for example, the use of x-rays, computed tomography (CT), or magnetic resonance imaging (MRI). Microscopic analysis may involve low-power magnification to enhance visual examinations, or the preparation of histological thin sections (histology, or the study of the microstructure of a tissue) to examine a material's microstructure. Elemental analysis involves the assessment of the elemental or isotopic composition of the material using x-ray fluorescence spectrometry (XRF).

Figure 2: Radiographic examination of a human cranium. (FBI anthropology case files)

These aforementioned methods are used in determining whether a suspected material is bone, determining whether bone is human or non-human in origin, facilitating person identification by helping to narrow the pool of potential matches by assessing features of the skeleton (age, sex, ancestry, stature, individual variants) as well as determining the likelihood of an identification by comparing antemortem and postmortem skeletal information, and assessing skeletal alterations due to trauma and damage. Additional details about each method are described below. In many cases, these analyses are performed by comparing the material with information or data from published literature (including bone-, age-, sex- and ancestry-specific studies appearing in peer-reviewed journals or texts) or skeletal reference material (including bones, replicas or casts).

The conclusions that can be reached from anthropological examinations are often dependent on the condition and completeness of the material, the availability and quality of antemortem data, and the analytical approaches used. Although suites of traits and metric relationships are understood to characterize certain groups (such as males and females, ancestral groups, and age groups), no particular feature or measurement is considered diagnostic of membership in any one particular group due to variation in the human species arising from genetic and external factors. Although skeletal alterations are governed by bone biomechanical laws which show relationships with certain known causes, the variety and complexity of factors that may contribute to the disruption of skeletal tissues often make it difficult to determine the timing or mechanism of trauma with certainty. Anthropological conclusions are therefore rarely definitive.

A. Skeletal or Non-Skeletal Origin

Skeletal material includes both osseous (bone) and dental (tooth) tissue. It is sometimes necessary to determine whether a material is skeletal in origin versus some other material. Visual examination can be used to assess the material for the presence or absence of features or structures that characterize osseous or dental tissue including overall size and morphology, landmarks, trabeculae (a feature of bone structure), density, and color. The material can also be evaluated by microscopic examination to include the preparation of histological sections to look for microstructures consistent with skeletal material (such as osteons, the primary units of bone). Radiographic examination can also be used, assessing the material for features that characterize osseous or dental tissue such as morphology, landmarks and trabeculae. The material can also be evaluated using X-ray fluorescence spectrometry (XRF), assessing the material for its elemental components, with skeletal material being characterized by particular levels of calcium and phosphorus (see Figure 3).[2]

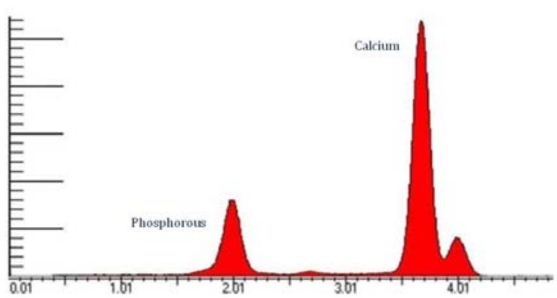

Figure 3: Elemental (XRF) profile of skeletal material. (modified from Christensen et al., 2012)

[2] *See, e.g.*, A.M. Christensen, M.A. Smith & R.M. Thomas, *Validation of X-ray fluorescence spectrometry to determine osseous or dental origin of unknown material*, 57 J. of Forensic Sci., no. 1, 47-51 (2012), *and* D.H. Ubelaker, D.C. Ward, V.S. Braz & J.E.B. Stewart, *The use of SEM/EDS analysis to distinguish dental and osseous tissue from other materials*, J. of Forensic Sci., no. 47, 940-43 (2002).

Conclusions by Department forensic anthropologists typically include the determination that (1) the material submitted for examination is skeletal (osseous or dental) in origin based on features (morphological, metric, elemental, etc.) that are consistent with osseous or dental tissue; (2) that the material is non-skeletal in origin based on the absence of features consistent with skeletal tissue or features that are inconsistent with skeletal tissue; or (3) that the material is of undetermined origin.

B. Human or Non-Human Origin

It is often necessary to determine whether skeletal material is human or non-human in origin. (Note that non-human skeletal material can still be forensically significant, for example in poaching or animal abuse cases). Though they share many characteristics, the bones of different animal species show significant variation in morphology and microstructure. The determination of whether skeletal material is human or non-human in origin can usually be achieved by visual examination of bone morphology if the specimens are sufficiently large and in good condition, using the examiner's professional training and knowledge of human and non-human osteology. The material can also be compared to information or data from published literature including but not limited to *Comparative Skeletal Anatomy: A Photographic Atlas for Medical Examiners, Coroners, Forensic Anthropologists, and Archaeologists* (Adams and Crabtree, 2008) or *Human and Non-human Bone Identification: A Color Atlas* (France, 2008) (Figure 4) or skeletal exemplars. Many non-human skeletal exemplars are available in the FBI Forensic Anthropology Program's (FAP) *Skeletal Reference Collection*, a collection of known non-human skeletal specimens that can be used for direct comparison of bone morphology. Collections at the Smithsonian Institution's National Museum of Natural History can also be utilized for comparative purposes. In some cases, the material can be assessed quantitatively/metrically to determine whether it is within the known range of size variation for human skeletal material.

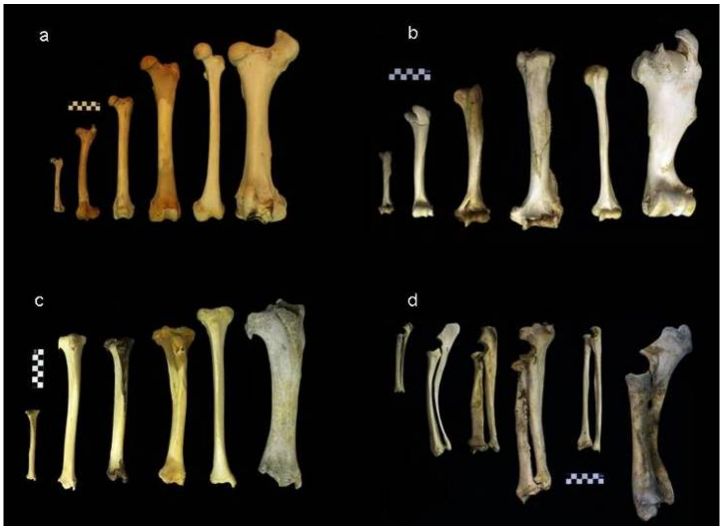

Figure 4: Morphological differences between the femora (a), humeri (b), tibiae (c) and radii/ulnae (d) of human and various non-human species. (Christensen et al., 2014)

The bones of many species also have different microstructural characteristics.[3] Histomorphological analysis can be used to assess for the presence of Haversian (osteonal) bone microstructure which characterizes human bone (as well as some non-human bone), or non-Haversian (fibrolamellar, laminar, and plexiform) bone which characterizes many non-human bones (Figure 5). In some cases, the histological section can be compared with reference slides such as those in the FAP's *Skeletal Reference Collection* or image exemplars appearing in published literature.

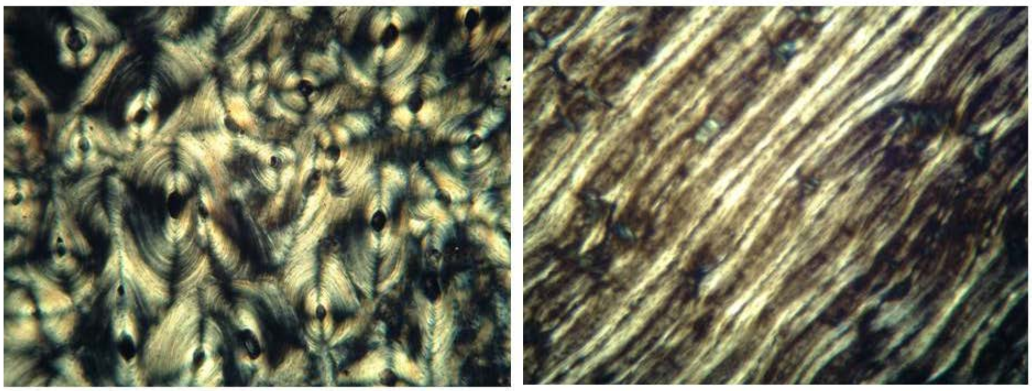

Figure 5: Histomorphological differences between Haversian bone in a human (left) and plexiform bone in a deer (right). (specimens from the FBI FAP *Skeletal Reference Collection*)

Conclusions by Department forensic anthropologists typically reached in the assessment of human versus non-human origin include the determination that the material is human in origin based on the presence of features, morphology or other characteristics that are consistent with human bone, or that the material is non-human in origin based on the presence of features, morphology or other characteristics that are inconsistent with human bone or are consistent with non-human bone.

If bone histomorphological analysis is used, conclusions that can be reached include the determination that non-Haversian bone is present and therefore human origin can be excluded, or that Haversian bone is present and therefore human origin cannot be excluded.

C. Biological Profile

The skeleton reflects a number of aspects of an individual's biology and life history, and as a result, certain biological parameters can often be estimated from parts of the skeleton including sex (male or female), age (years of age at death), ancestry (geographic ancestral origins), and stature (living height), as well as evidence of disease processes, skeletal anomalies, and previous injuries.

[3] *See*, *e.g.*, C. Crowder & S. Stout, *Bone Histology: An Anthropological Perspective*, Boca Raton, Fla., CRC Press (2012).

Sex

Sex can be estimated by observing bones that are sexually dimorphic, or sized and shaped differently in males and females. Sex assessment is typically performed using non-metric and metric approaches that examine sexually dimorphic characteristics of the skeleton. Bones that are known to exhibit the greatest sexual dimorphism such as the pelvis (see Figure 6), long bones, and skull are preferentially examined, though other bones can also be used.[4] For metric assessments, multivariate techniques may be used and measurements may be compared against known populations using software such as Fordisc.[5] These metric approaches can provide the examiner with a statistically-based estimation of sex.

Figure 6: Morphological differences between the female (left) and male (right) pelvis. (Christensen et al., 2014)

Conclusions by Department forensic anthropologists typically reached in the estimation of sex include the determination that the features/measurements of the material are most similar to those of either males or females. Posterior probabilities and typicalities are usually reported, or at least documented, in the case notes.

Age

Age estimation is based on the evaluation of skeletal development (for subadults) or degenerative change (for adults). In most cases, age estimation is performed by visual assessment, though radiography may also be useful. For subadults, methods include the assessment of dental development,[6] including tooth formation and eruption (Figure 7), as well as

[4] *See, e.g.*, T.W. Phenice, *A newly developed visual method of sexing the os pubis, Am. J. of Physical Anthropology*, no. 30, 297-302 (1969), *and* M.K. Spradley & R.L. Jantz, *Sex estimation in forensic anthropology: Skull versus postcranial elements*, J. of Forensic Sci., no. 56, 289-96 (2011).

[5] Fordisc is a discriminant function program used to assist in the assessment of sex, ancestry and stature from skeletal remains based on metric similarities to known reference populations.

[6] *See, e.g.*, C.F.A. Moorrees, E.A. Fanning & E.E. Hunt Jr., *Age variation of formation stages for ten permanent teeth*, J. of Dental Research, no. 42, 1490-1502 (1963); H.H. Mincer, E.F. Harris & H.E. Berryman, *The A.B.F.A. study of third molar development and its use as an estimator of chronological age*, 38 J. of Forensic Sci., no. 2, 379-90 (1993); *and* D.H. Ubelaker, *Human Skeletal Remains: Excavation, Analysis and Interpretation*, Taraxacum (1999).

bone development, including ossification, growth, and epiphyseal union.[7] Methods involving dental development are preferred because dental development is more strongly correlated with chronological age than is bone development. For adults, degenerative changes, including those associated with pubic symphyseal morphology,[8] sternal rib ends,[9] and overall skeletal health, can suggest chronological age, though these are less strongly correlated with age than skeletal development.

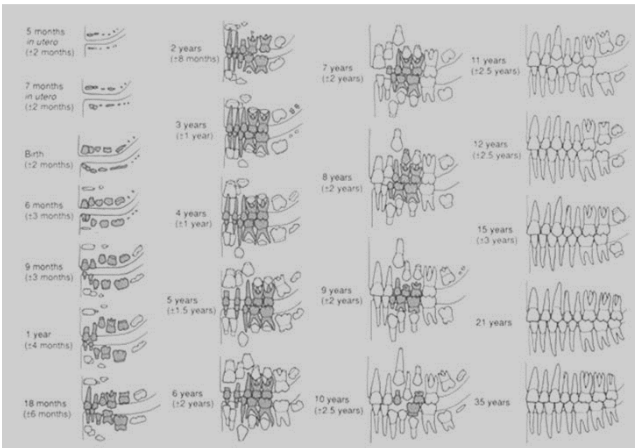

Figure 7: Tooth formation and eruption. (Ubelaker, 1999)

Conclusions by Department forensic anthropologists typically reached in the estimation of age are reported as an interval, with the size of the interval dependent on the strength of the correlation between chronological and physiological age based on what feature is being evaluated; intervals will typically be smaller for children versus adults. Probabilities can be reported when permitted by the approach.

Ancestry

Ancestry estimation is based on the evaluation of characteristics that show variation between geographic groups. These differences are expressed primarily in features of the skull. Certain non-metric traits (such as some dental features) may suggest a particular ancestral group,[10] but

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[7] *See, e.g.*, J.L. Scheuer & S.M. Black, *Developmental Juvenile Osteology* (2000).

[8] *See, e.g.*, D. Katz & J.M. Suchey, *Age determination of the male os pubis*, Am. J. of Physical Anthropology, no. 69, 427-35 (1986), *and* K.M. Harnett, *Analysis of age-at-death estimation using data from a new, modern autopsy sample – part 1: pubic bone*, J. of Forensic Sci., no. 55, 1145-51 (2010).

[9] *See, e.g.*, S.T. Loth & M.Y. Iscan, *Morphological assessment of age in the adult: The thoracic region*, in MY Iscan (Ed), *Age Markers in the Human Skeleton*, 105-36 (1989); *and* K.M. Harnett, *Analysis of age-at-death estimation using data from a new, modern autopsy* sample – *part 2: sternal end of first rib*, J. of Forensic Sci., no. 55, 1152-56 (2010).

[10] *See, e.g.*, J.T. Hefner JT, *Cranial nonmetric variation and estimating ancestry*, 54 J. of Forensic Sci., no. 5, 985-95 (2009), *and* G.W. Gill & S. Rhine, *Skeletal Attribution of Race: Methods for Forensic Anthropology*, Maxwell Museum of Anthropological Papers no. 4, U. of N.M. (1990).

metric methods using Fordisc (Figure 8) are preferred. Metric analysis using Fordisc allows the assessment of the similarity of the measurements of an unidentified individual to measurements of individuals of known sex and ancestry. Data output from Fordisc includes, among other statistics, a posterior probability and a typicality probability. The posterior probability represents the *relative* similarity of the measurements from the unknown skeleton to the groups with which it is compared (i.e., which of the selected reference groups the skeletal measurements mostly closely resemble). The typicality probability represents the *absolute* similarity to the comparison groups (i.e., how “typical” the measurements are of the selected reference groups) (Figure 9). Fordisc therefore does not provide a definitive determination of ancestry, but the statistically-based results are used as part of an assessment of the probable or likely ancestral affiliation of the unknown remains.

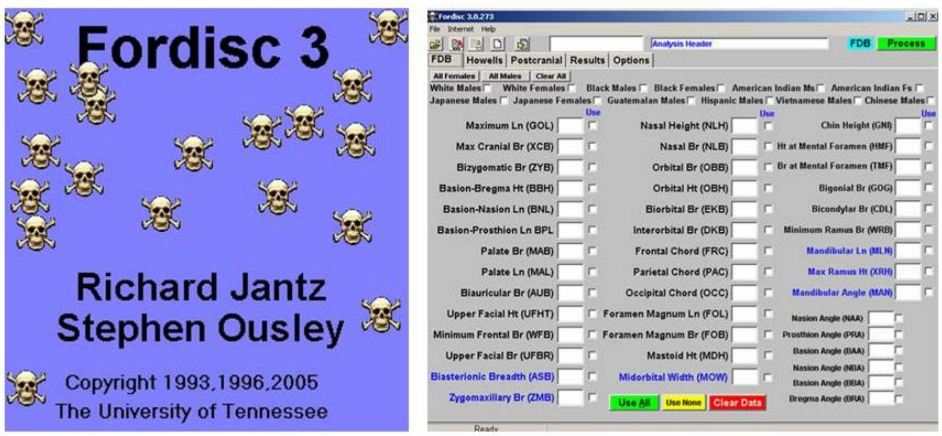

Figure 8: Fordisc software for discriminant function analysis of skeletal measurements. (Ousley and Jantz, 2005).

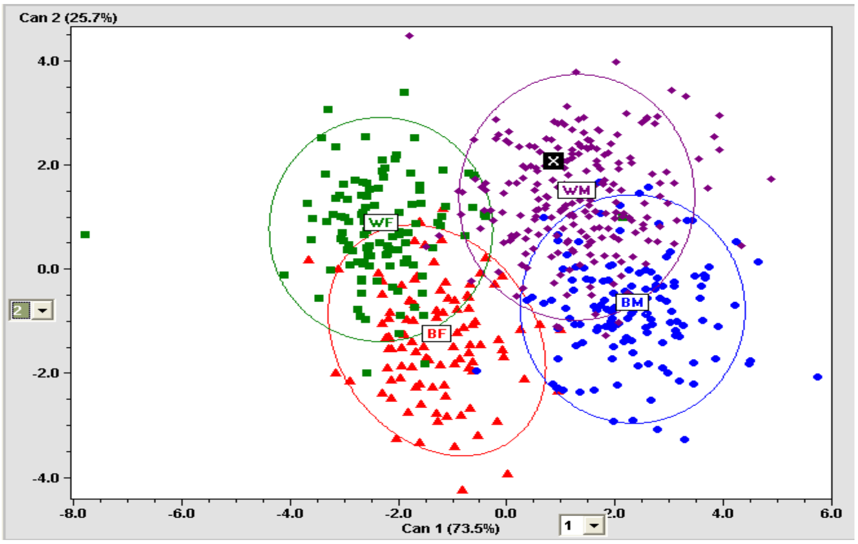

Figure 9: Fordisc graphical output of an analysis comparing measurements of unknown skeletal remains with those of White Females (WF), White Males (WM), Black Females (BF) and Black Males (BF) in the Fordisc reference database. In this case, results indicate that the measurements of the unknown skeleton (represented by the black "X") are most similar to White Males, and are also typical (near the centroid) of White males. This case would have high posterior and typicality probabilities for a White Male classification.

Conclusions by Department forensic anthropologists typically reached in the estimation of ancestry include the determination that the features/measurements of the material are most similar to those of a particular known ancestral group, but in some cases, ancestry assessments may be reported as "undetermined." Posterior probabilities and typicalities are usually reported or at least documented in the case notes (for example, stating the calculated posterior and typicality probabilities when compared to particular groups using Fordisc).

Stature

Stature estimation is based on the relationship between bone lengths and height. Methods include the anatomical method or regression methods. The anatomical method involves summing the heights of all bones comprising stature and applying a correction for soft tissue.[11] Regression methods involve calculating stature based on population-specific regression formulae describing the relationship between stature and particular bones (or portions thereof).[12]

Conclusions by Department forensic anthropologists regarding stature estimation are typically reported as an interval, usually a 95% confidence interval when based on regression methods. These calculations can be performed manually, but are most often calculated using Fordisc where prediction intervals can be selected by the user.

[11] Fully G., *Un nouvelle method de determination de la taille*, Annales de Medicine Legale, no. 35, 266-73 (1956).

[12] M. Trotter & G.C. Gleser, *Estimation of stature from long bones of American Whites and Negroes*, Am. J. of Physical Anthropology no. 10, 463-514 (1952).

The assessment of skeletal anomalies including individual variants, disease and previous trauma is based on the analyst's knowledge of normal human skeletal anatomy and variation, and the recognition of these conditions as variants from normal human skeletal anatomy. These variants can usually be identified through differential diagnosis and comparison to exemplars or published literature including but not limited to *Identification of Pathological Conditions in Human Skeletal Remains* (Ortner, 2003), *Photographic Regional Atlas of Bone Disease: A Guide to Pathologic and Normal Variation in the Human Skeleton* (Mann and Hunt, 2005), and *Atlas of Developmental Field Anomalies of the Human Skeleton* (Barnes, 2012).

Conclusions by Department forensic anthropologists typically reached in the assessment of skeletal variations/conditions (such as antemortem injuries, pathological conditions, or skeletal anomalies) include the determination that the variants observed are consistent with certain skeletal conditions (or several possibilities). In some cases, other conditions that may have similar skeletal presentations cannot be excluded; in such cases, this will be stated.

D. Personal Identification

In cases where the identity of a decedent has been suggested by investigators, known information and records from the presumed decedent (antemortem information) can be compared with the skeletal information (postmortem information) to determine whether they are consistent with originating from the same person (Figure 10). Antemortem information may include medical and dental records (including images, charts and notes), biological information (age, sex, ancestry, stature, individual skeletal variants), or photographs.

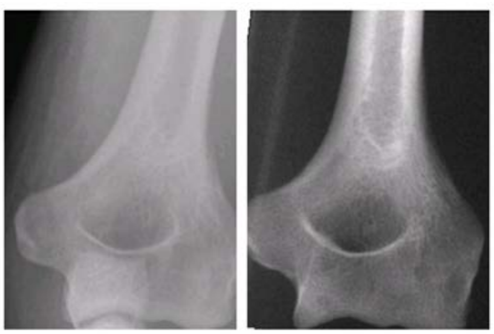

Figure 10: Antemortem (left) and postmortem (right) radiographs of a human arm. (FBI anthropology case files)

While the results of an anthropological comparison may facilitate the identification process, the conclusion that a positive personal identification has been made is not reported by forensic anthropologists. The identification of deceased individuals (defined by the completion of a death certificate) is a legal determination and is the responsibility of the medicolegal authority in the jurisdiction in which the remains were discovered.

E. Trauma Analysis

Trauma involves the disruption of living tissue by an outside force. Alterations to the skeleton resulting from trauma may be assessed in anthropological examinations. Trauma can be detected by visual, microscopic, or radiographic examination and is typically classified by timing and mechanism. The interpretation of skeletal trauma is based on principles of bone physiology and fracture repair, as well as bone biomechanics and fracture mechanics.[13]

Timing of trauma can be antemortem, perimortem, or postmortem. Antemortem trauma refers to an injury that occurred prior to death, and is determined on the basis of osteogenic reaction (healing). Perimortem trauma refers to an injury that occurred around the time of death, but is classified on the basis of biomechanical characteristics of fresh bone regardless of the temporal relationship to the death event. These traumas lack healing, and are evidenced by features including but not limited to fracture characteristics of fresh bone.[14] Postmortem damage refers to taphonomic alterations to bone after death and are unassociated to the death event. These traumas lack healing, and are evidenced by features including but not limited to fracture characteristics of dry bone.[15]

The mechanisms of trauma are classified as high-velocity projectile, blunt, sharp, or thermal forces. High velocity projectile trauma is produced by impact from a projectile traveling at a high rate of speed, and is characterized by features such as beveling, certain patterns of missing and fractured bone, and projectile remnants (Figure 11).[16] Blunt force trauma is produced by a low velocity impact from a blunt object or the low velocity impact of a body with a blunt surface. It is characterized by features including but not limited to plastic deformation, tool marks, and certain fracture patterns.[17] Sharp force trauma occurs from edged, pointed, or beveled objects. It is characterized by features such as kerfs, incised alterations, and punctures.[18] Thermal trauma is produced by exposure to high temperatures or flame (or sometimes chemicals) and is characterized by features including but not limited to color change, shrinkage, and certain fracture patterns (Figure 12).[19] For certain types of skeletal trauma where apparent

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[13] *See, e.g.*, S.C. Cowin, *Bone Biomechanics Handbook* (2001); R.B. Martin, D.B. Burr, & N.A. Sharkey, *Skeletal Tissue Mechanics* (1998); *and* J.D. Currey, *The mechanical properties of bone*, Clinical Orthopaedics, 73, 210-31 (1970).

[14] SWGANTH, Best Practice Guidelines for *Trauma Analysis*, *Revision 0 (2011)*, www.swganth.org (last visited March 23, 2015).

[15] SWGANTH, Best Practice Guidelines for *Trauma Analysis*, *Revision 0 (2011)*, www.swganth.org (last visited March 23, 2015).

[16] *See, e.g.*, H.E. Berryman & S.A. Symes, *Recognizing gunshot and blunt cranial trauma through fracture interpretation*, In Reich KJ (Ed.), Forensic Osteology: Advances in the Identification of Human Remains (1998).

[17] *See, e.g.*, A. Galloway, *Broken Bones: Anthropological Analysis of Blunt Force Trauma* (1999); *and* H.E. Berryman & S.A. Symes, *Recognizing gunshot and blunt cranial trauma through fracture interpretation*, In Reichs KJ (Ed.), Forensic Osteology: Advances in the Identification of Human Remains (1998).

[18] S.A. Symes, et al., *Knife and saw toolmark analysis on bone: A manual designed for the examination of criminal mutilation and dismemberment*, National Institute of Justice Report, Document Number 232864 (2010).

[19] C. Schmidt & S. Symes, *The Analysis of Burned Human Remains* (2008).

toolmarks are present (particularly those relating to sharp and certain blunt force traumas), the evidence may be referred to toolmarks examiners for additional analysis (Figure 13).

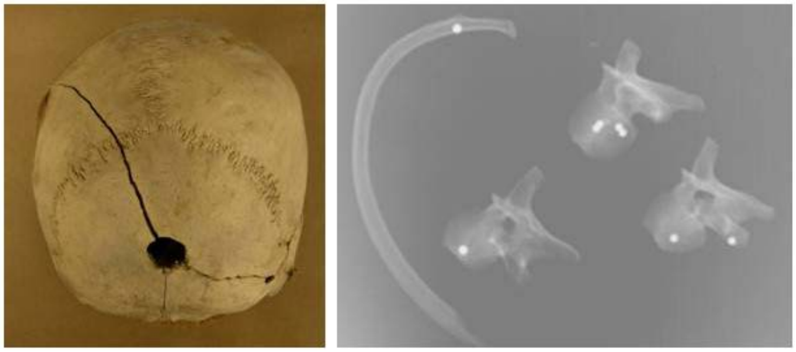

Figure 11: Fractures and missing bone (left) and projectiles visible in radiograph resulting from high-velocity projectile trauma. (FBI anthropology case files)

Figure 12: Thermal alteration to bone. (FBI anthropology case files)

Figure 13: Cut mark on a vertebra; this case would be referred to toolmark examiners. (FBI anthropology case files).

Conclusions typically reached in the analysis of skeletal trauma include the determination that timing and mechanism of the trauma are consistent with a particular timing and/or mechanism. When a distinction cannot be made, this is clearly stated.

While the results of an anthropological trauma analysis may provide insight into the circumstances of death, conclusions regarding the cause and manner of death are not reported by forensic anthropologists. The determination of the cause/manner of death is the responsibility of the medicolegal authority (typically a medical examiner or coroner) in the jurisdiction in which the remains were discovered.

Policy Considerations

In 2006, Congress authorized the National Academy of Sciences to conduct a study on forensic science, which culminated in a 2009 report. While the NAS report did not provide specific criticism or guidance regarding forensic anthropology, it did refer to it as a laboratory based discipline. An overall criticism of forensic science by the NAS was the need for research and empirical data to support conclusions drawn by examiners during forensic analysis.