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**Standard for Analyzing Skeletal Trauma
in Forensic Anthropology**

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Standard for Analyzing Skeletal Trauma in Forensic Anthropology

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Foreword

This standard was developed to provide guidance to practitioners ~~in~~^{for} recognizing, describing, interpreting, and reporting trauma in skeletal material. Trauma analysis is a component of anthropologic examination needed to identify traumatic events occurring before, during, and after death. This document is intended to assist forensic anthropologists when assessing trauma from skeletal elements.

This document was revised, prepared, and finalized as a standard by the Anthropology Consensus Body of the AAFS Standards Board. The draft of this standard was developed by the Anthropology Subcommittee of the Organization of Scientific Area Committees (OSAC) for Forensic Science.

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All hyperlinks and web addresses shown in this document are current as of the publication date of this standard.

Keywords: *trauma analysis; skeletal examination; trauma timing; trauma mechanism*

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Standard for Analyzing Skeletal Trauma in Forensic Anthropology

1 Scope

This standard provides requirements for documenting, describing, interpreting, and reporting skeletal trauma in forensic anthropology. It also provides requirements for the determination of trauma timing (i.e., antemortem, perimortem, or postmortem) and the identification of the mechanism that produced the trauma (i.e., projectile, sharp, blunt, or thermal trauma). This document does not address cause and manner of death.

2 Normative References

There are no normative reference documents.

3 Terms and Definitions

For purposes of this document, the following definitions apply.

3.1

antemortem trauma

A skeletal defect that occurred before an individual's death ~~with~~ and shows evidence of ~~biological~~ osteological reaction.

3.2

blunt trauma

A skeletal defect produced by low-velocity impact from a blunt object (e.g., being struck by an object or concussive wave) or the low-velocity impact of a body with a blunt surface (e.g., motor vehicle accident or fall).

3.3

delamination

A separation of cortical and cancellous bone.

3.4

kerf

The notch or groove in bone, tooth, or cartilage made by an object that is edged, pointed, or beveled.

3.5

perimortem trauma

A skeletal defect that occurred when bone is in a biomechanically fresh (visco-elastic) state with no evidence of ~~healing~~ osteological reaction.

3.6

plastic deformation

A permanent distortion of ~~bone shape~~ bone's shape without fracture caused by a force exceeding an element's elastic limit/elastic modulus/yield point.

3.7

postmortem damage

A skeletal defect that occurred after a bone has lost its biomechanically fresh (visco-elastic) properties.

3.8

projectile trauma

A skeletal defect produced by high velocity, rapid application of force over a relatively small surface area, typically by projectiles from firearms but can result from any small object impacting a bone at a high velocity.

3.9

sharp trauma

A skeletal defect produced by an object that is edged, pointed, or beveled.

3.10

skeletal trauma

A defect to osseous, dental, and/or cartilaginous tissue as a result of external forces.

3.11

spatial distribution

The locations of defects (or damage/breakage) in relation to each other throughout the skeleton.

3.12

thermal trauma

A skeletal defect produced by exposure to high temperature or direct contact with flame.

3.1213

trauma description

Reporting of the location, dimension(s), and other observed characteristics of the skeletal defect(s).

3.1314

trauma interpretation

~~Estimation or conclusion~~Opinion regarding the mechanism ~~of timing, direction of impact(s) or~~ minimum number of impacts associated with skeletal defect(s) based on quantitative and/or qualitative observations.

3.1415

trauma mechanism

The ~~mechanism~~classification of an extrinsic factor that produces a skeletal ~~defects and may be~~ classified as projectile, sharp, blunt, or thermal trauma.defect.

4 Requirements

4.1 General

Skeletal trauma shall be examined ~~grossly, microscopically.~~ Acceptable methods to examine trauma include gross, microscopic, radiographic, and/or radiographically other analytical methods.

Documentation of trauma shall be adequate to allow independent verification of work performed in the absence of the original specimen.

Skeletal material shall be assessed and evidence of trauma and/or damage shall be documented before and after processing. The cranium should be opened and a complete endocranial examination conducted. Ideally, the endocranial examination should occur after ectocranial trauma is documented. ~~and other cranial data are collected.~~

Documentation of skeletal trauma shall include written descriptions as well as ~~images~~ visual representations (i.e., photographs, diagrams/sketches, ~~and/or~~ radiographs, ~~casts~~, 3D scanning). Descriptions shall include the location and characteristics of the skeletal defect. Trauma location shall be documented using standard osteological/anatomical terms. When multiple defects are present, the spatial distribution pattern shall be documented and described. Dimensions of skeletal defects resulting from trauma should be measured, ~~when appropriate.~~

Foreign material (e.g., hair, fibers, bullet fragments, ~~knifeblade~~ tip) associated with a skeletal defect shall be documented and described. ~~When possible, guidance regarding collecting the foreign material should be sought from a qualified individual, and an individual competent in material evidence analysis may be collected. An anthropologist shall not analyze the material these materials unless qualified.~~

A distinction shall be drawn between trauma description and interpretation. At a minimum, a ~~trauma~~ description of the defect(s) shall be given. Trauma interpretation shall be limited to when the evidence clearly supports the findings.

4.2— Procedure

4.34.2 Trauma Timing

4.2.1 General

Defect characteristics ~~and morphology~~ shall be used to assess when the skeletal element was traumatized or damaged. ~~Trauma timing~~ Timing of the defect shall be classified, using terms such as antemortem, perimortem, or postmortem. When a distinction in timing cannot be made between antemortem, perimortem, and postmortem ~~timing~~, the limitations shall be clearly documented and reported.

4.2.2 Antemortem Trauma

~~Features that indicate antemortem~~ Antemortem trauma shall be documented (e.g., photographed), described and reported and identified based on the presence of a trauma-related osteological reaction. These reactions may include observations such as healed fractures or evidence of healing, development of pseudarthrosis, ~~trauma-induced~~ degenerative joint disease, infectious response, dental ~~fractures~~ fracture with worn or rounded fracture margins margin, and a surgically implanted ~~devices~~ device.

Practitioners shall not ~~offer an opinion as to the cause of~~ provide a trauma interpretation for antemortem trauma except in cases that show identifiable features and patterning or radiographic evidence of identifiable foreign bodies.

4.2.3 Perimortem Trauma

Perimortem trauma shall be identified based on ~~the basis of~~ the presence of biomechanical characteristics indicative of fresh bone or the incontrovertible association of the trauma with the incident that produced it (e.g., explosion, fire, plane crash, fall from a building). Presence of biomechanical characteristics shall include: lack of osteological reaction ~~(e.g., healing or infectious response)~~, presence of fresh bone fracture characteristics ~~(e.g., plastic response)~~, and ~~or~~ absence of dry bone fracture characteristics ~~(e.g., angular fractures)~~. Classification of trauma as perimortem is strengthened when the mechanism or indicators can be identified (e.g., hair entrapped in bone with associated blunt trauma injuries, the presence of blood staining, or ~~imbedded~~ embedded debris from a fall from a building).

4.2.4 Postmortem Damage

~~Features that indicate postmortem~~ Postmortem damage shall be ~~documented and include observations such as~~ identified based on differentially stained or recently exposed surfaces, absence of healing, characteristics of the break lacking biomechanically fresh (visco-elastic) properties, and ~~or~~ changes resulting from taphonomic events.

When defects are classified as postmortem, terms such as “damage” and “breakage” should be used. The ~~term~~ terms “trauma” and “fracture” should be reserved for antemortem and perimortem trauma.

4.3 Trauma Mechanism

4.3.1 General

Trauma mechanism classification shall be based on defect shape and size, ~~defect~~ spatial distribution ~~pattern~~, and ~~or~~ evidence of plastic deformation. Extrinsic, continuously variable and concurrent factors such as velocity and force may preclude ~~assignment~~ classification of trauma mechanism ~~into discrete categories (e.g., blunt, sharp trauma)~~. ~~When the trauma, sharp trauma)~~. ~~When a distinction~~ mechanism cannot be ~~made between projectile, blunt trauma, and sharp trauma~~ classified, the defect shall be clearly described, documented, and reported without interpretation.

Fractured bones shall be ~~re-approximated, and may be~~ reconstructed, ~~when possible~~, to clearly assess defect features and their spatial distribution. Fracture margins and fracture surfaces shall be examined prior to reconstruction and a reversible medium should be used. When possible, observed fracture patterns should be compared to reference material to aid in trauma mechanism classification.

No conclusions regarding ~~wound~~ defect sequencing shall be provided unless there are clear indications of the order of defects (e.g., a ~~radiating~~ fracture terminating at a preexisting fracture).

4.3.2 Projectile Trauma

~~A projectile trauma defect is produced by rapid application of force over a relatively small surface area, typically by projectiles from firearms, but can result from any small object impacting a bone at a high velocity.~~ Observed features indicating projectile trauma ~~shall be documented and~~ may include: a projectile in association with the bone, entrance or exit ~~wound~~ defect characteristics, residue, bullet wipe, ~~or~~ remnants of the projectile, fracture pattern with minimal to no plastic deformation, and concentric beveling that indicates an internal to external force.

~~When present~~In the context of projectile trauma, plastic deformation may indicate a lower velocity projectile, a projectile slowed before impact, or other energy loss during flight.

When possible, entrance and exit ~~wounds~~defects shall include descriptions and photographs of internal and external beveling, defect measurement ~~(i.e., defect diameter)~~, anatomic location, associated fracture patterns, and estimation of projectile path relative to anatomical position.

The presence of projectile residue (e.g., soot and other materials discharged from a firearm, staining from extended contact with metal, embedded metallic/radiodense artifacts) shall be documented. The term “bullet wipe” is preferred to “lead wipe,” since the outer surface of a bullet may be composed of materials other than lead.

Practitioners shall not ~~opine on~~estimate or report bullet caliber ~~from measurement of the entrance wound~~. Estimates of muzzle to target distance shall be made with caution and supported by skeletal findings. Practitioners ~~may~~should describe the spread of shotgun pellets, presence of wadding, or shot cup, which may be ~~indicative~~informative of distance.

4.3.3 Blunt Trauma

~~A blunt trauma defect is produced by a low-velocity impact from a blunt object or the low-velocity impact of a body with a blunt surface.~~Observed features ~~indicating of~~ blunt trauma ~~shall be documented and~~ may include: fracture patterns with plastic deformation, delamination, or ~~concentric~~beveling of the cranial vault indicative of external to internal force. Features ~~indicative of~~ an impact site (i.e., depressed fractures, ~~concentric/circumferential~~ fractures, tool marks, ~~fracture patterns~~) shall be documented. ~~Latent impact sites on the cranium in the form of dark stains resulting~~ Staining, which may result from ~~entrapped~~ blood and fat within crushed ~~diploë~~ shall ~~diploë, and other alterations which may represent impact sites shall also~~ be documented.

The use of standard clinical terms (e.g., ~~parry~~Parry, Colles) and orthopedic classification systems (e.g., Le Fort, Salter-Harris ~~Type II~~ fractures) should be used with caution to avoid non-skeletal implications ~~and/or~~ interpretation.

An interpretation of the minimum number of impacts and direction of impact(s) should be documented, when possible.

4.3.4 Sharp Trauma

~~A sharp trauma defect is produced by an object that is edged, pointed, or beveled. Observed features indicating sharp trauma shall be documented and~~Observed features of sharp trauma may include: straight-line incised defects, punctures or gouges, chop or hack marks (clefts), and kerfs. Defect features such as length, width, depth, and inter-striation distance should be measured, and casts made when possible. Sharp trauma defects and their casts shall be examined grossly and microscopically.

Defect features may reflect class characteristics of the tool and shall be interpreted to identify tool type/class and not individual tools. ~~Practitioners shall not determine a “match” between a specific tool and a tool mark~~ The type and spatial distribution of sharp force trauma may indicate ~~dismemberment~~.

Fractures often occur in association with sharp trauma and shall be ~~described~~documented, if present. Features common with pseudo-sharp trauma, such as ~~serape, scores~~scrapes, scores, and

scratch marks, shall be documented. Tool marks in bone or cartilage shall not be identified as hesitation marks.

4.3.5 Thermal Trauma

~~A thermal trauma defect is produced by exposure to high temperature or direct contact with flame. Observed features indicating thermal trauma shall be documented and~~ Observed features of thermal trauma may include: color changes (e.g., yellow, black, white), delamination, burn pattern, shrinkage, charring, calcination, or heat-related fracture patterns. Thermal fracture location(s) and type(s) shall be documented. Features indicating that the bone was biomechanically dry during burning (e.g., absence of warping, ~~absence of curvilinear fractures~~) shall be documented. Skeletal defects inconsistent with When thermal trauma and other trauma (e.g., sharp, blunt, projectile) coexist, all trauma types shall be ~~documented.~~

clearly delineated in the documentation. Aberrant patterns of burning (i.e., patterns that ~~do not follow~~ are inconsistent with those expected due to tissue shielding) may provide information about body positioning, presence of trauma (e.g., dismemberment), or postmortem interval (e.g., lack of pugilistic posture) and shall be documented.

Practitioners shall not estimate the temperature or duration of heat exposure ~~from traumatized~~ based on thermal defects to bone characteristics.

5 Considerations and Adjustments

The term “perimortem” is used differently by pathologists and anthropologists. The timing of injury is less precise when evaluating bone than when evaluating soft tissue. Based upon the intrinsic properties of bone, the perimortem interval extends from days preceding death to days to weeks following the death event. When working with skeletal or decomposed remains and perimortem trauma is identified, a forensic anthropological definition of “perimortem” should be included in the report.

~~The~~ possibility spatial distribution of fractures shall be considered to evaluate whether the fractures occurred from a single impact/~~injury~~ event resulting in fractures of several bones (e.g., a fall resulting in serial rib fractures) ~~shall be documented.~~

~~Intrinsic factors~~ Factors that may influence skeletal trauma (including e.g., decedent age, sex, health status ~~and comorbidities as well as~~; bone and fracture type ~~and~~; fracture location) shall be considered in skeletal trauma interpretation. These factors ~~should be especially considered~~ are particularly important when assessing age of injury. For example, an adult healing phase assessment ~~should~~ shall not be applied to an infant.

~~In addition to skeletal defects, cartilage may also be analyzed as a component of skeletal trauma analysis.~~

~~When evaluating skeletal trauma, pathological~~ Pathological conditions, anomalies, or taphonomic changes may mimic skeletal trauma.

~~Forensic anthropologists are responsible for identifying, documenting, describing, and, if possible, interpreting skeletal trauma.~~ Practitioners shall not determine a “match” between a specific tool and a tool mark.

Forensic anthropologists shall not determine cause or manner of death. Blasts/explosive events often cause blunt (including concussive) and projectile trauma to the body. When the trauma pattern and circumstantial information support a blast event, the trauma mechanism should be classified as "blast trauma".

6 Reporting

The written report shall include descriptions of all relevant gross, microscopic, and radiological findings. Trauma location and spatial distribution pattern as related to anatomical position shall be reported. ~~When possible, fracture type and mechanism shall be reported.~~

~~Conclusive interpretation~~ Interpretation of trauma and its timing may not be possible due to the nature of the trauma or the condition of the skeletal material; equivocal results shall be reported as such. Trauma interpretation shall be clearly identified in the report using terms such as 'indicative of' and 'consistent with' or by using a subheading titled 'Interpretation.'

Practitioners may report the minimum number of traumatic events (e.g., blunt impacts, projectile entry defects, or sharp defects) observed skeletally, but shall not report a definitive maximum number of impacts, as skeletal trauma evidence may not reflect all impacts to the body.

~~Identification of a specific tool shall not be reported; rather, the characteristics of the defect shall be described.~~ When a suspect tool is submitted for analysis, similarities between the tool and defect may be reported; conclusions shall be reported in terms of an exclusion or failure to exclude.

~~With regard to report~~ Reporting shall avoid terminology, ~~guidance for the anthropologic use of the term perimortem should that may be included in the report, when applicable.~~ Terms considered inflammatory ~~or indicating, imply~~ a particular outcome ~~such as "or imply intent.~~ Terms to avoid include but are not limited to: victim" (vs. "decedent"), "weapon" (vs. "tool" or "object"), "violent", "painful", "fatal," "suffer" (as in "suffered an injury"), or "lethal" shall not be used. The term "hesitation mark" shall not be used to describe cut marks or saw marks in bone.

~~Original data such as photographs, casts, digital images, radiographs, and sketches shall be properly labeled, archived, and accessible.~~ ~~lethal.~~

When casts are made of traumatic defects, the method, materials, and any artifacts created shall be documented in the report or case file. When physical evidence is ~~recovered~~ collected from a traumatic defect (e.g., a projectile, blade tip), the disposition of the evidence shall be documented.

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