H82 Utilizing Taphonomy and Context to Distinguish Perimortem from Postmortem Trauma in Fire Deaths

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The goals of this presentation are to demonstrate interactions of fire environments with the condition and preservation of human remains; to illustrate the importance of correlating the in situ position of burned bone with lab analysis for differentiating skeletal traumatic injury from taphonomy of heat and fire; to introduce problems of interpreting original body position in structural fires; and to discuss spatial relationship models for human remains in advanced stages of cremation for purposes of scene reconstruction.

This presentation will impact the forensic community and/or humanity by introducing benefits of experimental modeling demonstrating how soft and hard tissues of the human body are affected by heat and how these results are applicable to forensic casework dealing with extensively burned human remains. This modeling has the potential to identify features differentiating preexisting traumatic injury created in fresh bone from postmortem fractures caused by taphonomic changes to bone by fire and heat.

With the exception of crematoriums, human remains rarely burn in ideal conditions free of structural debris, dynamic environmental change, or body shifting during the reduction process. Heat alone causes muscle shrinking and dehydration, thus repositioning arms, legs, torso, and head into the flexed 'pugilistic posture.' Fire simultaneously impacts the surrounding environment, reducing construction materials and collapsing exposed spatial areas into layers of debris. Environmental changes potentially aid preservation or produce further damage by impacting and fragmenting brittle burned bone. Reduction of supporting materials of furniture, floors, or levels also contributes to fragmentation and dispersed spatial relationships of remains. Similar to decomposition, favorable conditions of ample oxygenation, circulation, and fuels accelerate soft and hard tissue destruction by fire, whereas restricted conditions impede proper combustion, thus producing visual differences in final appearances of burned human remains left for forensic analysis. Considering these taphonomic variables can assist scene reconstruction and differentiation of heat-related fractures from preexisting traumatic injuries in fragmentary burned skeletal remains.

Experimental burn research with human cadavers served as a model for observing interactions of the body, environment, and heat-related changes to known position and preexisting trauma in soft tissue and bone. Remains were photographically documented prior to, during, and following burning in conditions replicating forensic fires. Analysis began with the in situ position of remains at the scene, noting deviations from known original positions, influence and degradation of construction materials, spatial relationships of remains, relative fragment size and distance from the body, and condition of traumatic injuries in bone following incineration.

Distorted repositioning of limbs are observable heat-related changes to skin and muscles. Living skeletal tissues undergo similar dynamic transformations where heat pyrolyses and removes organic components (lipids, collagen, protein, water), producing black carbonization or charred bone. Depletion of organic materials weakens structural properties of remaining inorganic bone, appearing as white or gray calcined bone after heat drives off remaining carbon. Color changes occur simultaneously with shrinking and deformation of remaining inorganic skeletal structures, creating heatrelated fractures and brittle bone. These are expected taphonomic processes for advanced stages of burned bone and are produced differently than traumatic injury in fresh bone from applied external force.

Preexisting wounds in fresh bone are vulnerable to thermal damage through accelerated exposure by penetrated tissues, abnormally positioned long bones from shrinking muscles, or exposed fracture margins, particularly in cranial bone. Exposure to heat caused soft tissue injuries, modeled by surgical incisions, to exaggerate wound morphology due to shrinking skin, muscle, and fat. Superficial soft tissue injuries were difficult to discern for advanced stages of cremation (calcination) in the absence of associated color or tool marks in bone. Skeletal fractures in long bones were overpowered by contracting muscles from heat, pulling broken margins apart like an open hinge. In thicker tissues shrinking muscles overlapped fractured ends embedding deeper into surrounding tissues, thus shortening the limb.

Evidence of preexisting skeletal fractures in long bones was best represented by correlating abnormal in situ positions with photographic images following extinguishment and skeletal analysis of reconstructed specimens. Cranial bone requires similar attention to the in situ position or distribution of fragments. Fragmentation results from biochemical reduction of organic materials from living bone (which leaves inorganic calcined bone and heat fractures), preexisting skeletal trauma, collapsed debris (walls, ceiling, roof, windshield), body shifting or falling during the fire, and/or handling and transport of fragile bone. Since traumatic fractures are produced by force impacting or penetrating fresh bone, it is possible to differentiate them from heat-related fractures produced by organic pyrolysis, shrinking, and deformation of inorganic skeletal structures. Traumatic fracture margins were eroded, weathered, and deformed from heat exposure and more noticeable in thinner cortical and cranial bone than thicker cortical structures.

Context at the scene is an invaluable source of information for investigating fire deaths. Time and intensity of heat exposure contribute to the progressive degradation of human remains. Bodies salvaged earlier sustain less tissue damage when compared to advanced or complete reduction by fire. Similar logic applies to structural materials surrounding the body. Degraded or collapsed materials can either reduce possibilities of finding intact skeletal remains because of increased impact and skeletal fragmentation, or create artificial protection with fallen debris shielding tissues of the body from heat. Documenting context and relationship of human remains within the immediate environment yields contributory information toward explaining burn patterns of the body and scene. However, caution should be given to interpreting original position or behavioral body language (protective stance) of the victim since contracting muscles alter the body's posture and throughout burning remains can shift position, become artificially restrained, fall, or become impacted and repositioned by larger debris. These factors provide challenges directly associated with their unique environments (structural, vehicular, public transportation, or mass disaster) and should be integrated with laboratory analysis of burned soft and skeletal tissues for reconstructing identity and differentiating perimortem traumatic injury from postmortem taphonomic changes to bone by fire. Examples of these differences will be illustrated with models from experimental burn research and forensic casework.

Burned Bone, Perimortem and Postmortem Trauma, Taphonomy