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Burned Bones as Important Forensic Evidence: A Review

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Abstract

Burned bones are significant forensic evidence but the question arises about the analysis of burned bones. By being a fragile commodity burned bones can be hard to analysis. Over the year many researchers have given their important inputs towards the examination of the burned bones but the standard for all the research remains missing. The paper focuses on providing a bridge between the studies and to give significant insights in the analysis and recovery of burned bones and how they are an important in analysing the different parameters of forensic anthropology.

Keywords: Forensic anthropology • Burned bones • Fire forensics • Forensic instrumentation • Age estimation • Race estimation • Recovery • Tophonomics

Abbreviations BT/TV: Bone Volume/Total Volume; Ct: Computed Tomography; Sem: Scanning Electron Microscopy; Tem: Transmission Electron Microscopy; Ci: Crystallinity; Index; Ftir; Fourier Transform Infrared Spectroscopy; Xrd: X-Ray Diffraction; Saxs: Small-Angle X-Ray Scattering.

Introduction

Forensic anthropology has emerged out to be a new exploratory branch of forensic science. It is a subfield of Physical anthropology which includes studying the evolution and diversity of primates with a major focus on Homo sapiens, but whereas the forensic anthropology is concerned with application approach of anthropological theories and methods into legal action [1]. Burning a crime scene or a phenomenon is the easiest way of concealing a crime and destroys the evidences therefore burned bones are one of the important topics of research in recent times. The structural composition of bones plays vital part in the thermal influence of the crime scene. Bones are made up of two parts the organic component of collagen type 1 and inorganic component which majorly includes Hydroxyapitite [2].

The reaction of heat on the bones follows a sequential process, these stages includes dehydration, decomposition, inversion and fusion. The stages are categorized according to the structural and compositional changes of the bone. These changes are defined as change in shape, composition, reduction in size, shrinkage, weight change, dimension change [3,4].

The sequential process is accompanied by colour change from dark brown to black, black to gray, and finally to white. The colour has been considered a reliable indicator of temperature, the colour may vary according to length of exposure, difference in heat and flame interaction, inside and outside exposure of bone will show a difference in colour variations as well [5].

With recent advancements new methods are being adopted to study the relationship of burned bones and temperature effect, including X ray imaging, X ray diffraction, small-angle X-ray scattering, FTIR, Micro CT scan, Micro structural analysis of bone, BV/TV content analysis, C-I index, thermo gravimetric, SEM, TEM [6].

The physical property of mammal bone has made it an important artefact in estimation of age at death and conditions of life before death [7].

Literature Review

Preliminary examination

The primary examination of burned bones involves the morphological and colour change study. As the loss of muscle tissue happens and bone is finally exposed to heat and fire, a series of significant changes happen in the structure, composition, size, shape and colour of the bone [4]. Who later also proposed the use of photo spectrometer for collecting bone colour.

Although such changes are reliable parameters of the study but changes like them can provide wrong judgements as well, as the pathological and tophonomic factors may influences the correct situation, examples such as sun exposure and soil discoloration can affect the colour change if bone. Colour change may prove to be a good indicator of temperature correlation with bone colour change, fire exposure, and duration but newer studies shows that colour

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change can also provide information for collagen and DNA content. The surface appearance was studied later by coding soil colour chart.

This association of surface colour and temperature was described later in three categories for estimating exposure of temperature. Pale brown to black for temperature up to 340°C light brown to gray up to 600°C and white in colour for above 650°C

A study conducted shows that the combination of fields of anthropology and archaeology together give rise to new realm of bio archaeology which can prove to be effective in understanding the whole concept of extraction, recovery, analysis , and preservation part of burned bones. The study also showed the effect of a range of temperature on the morphology of bone and the different in the weight due to different traumatic exposure, which in turn suggests the changes in the composition of the bone. The study was conducted through observation based approach using the photographic method, of the burned bone samples.

Secondary examination

The identifiable stages in cremation include dehydration with a heating temperature up to 600°C resulting in breaking of hydroxyl bonds, second stage is defined as decomposition with heating temperature of 500°C- 800°C and resulting in removal of organic material. 3rd stage is inversion resulting in loss of carbonate with a temperature range of 700°C-1100°C. The final stage is referred as fusion with heating temperature above 1600°C and observable changing in melting of crystals.

On a similar approach identified shrinkage of calcined bone for about less than 3% with average temperature at 700°C later noted that degree of shrinkage happens according to different dimension of bones and shrinkage mostly happening at epiphysis. He also pointed out the random arrangement of collagen fiber as factor of high shrinkage associated with tubercular region.

Adding on to the observation the structural observations were not visible when heated at 800°C as investigated but contradictory were still able to see the Haversian canal system even at high temperature as 800°C-1200°C and could distinguish between human and non-human bone. The same finding has also been documented by with the scanning electron microscope (SEM) to analyse human bone.

More interestingly there are more ways of identifying burned bones; one of them is the measurement of potential of crystallinity index (CI) – or splitting factor. The CI measures the order of composition and crystalline structure with in the bone. The hypothesis suggests that with increase in CI the size of crystal also increases and become more ordered. The process is positively affected by digenetic pathway, weathering and heat. The instrumental analysis of CI includes through X-ray diffraction (XRD), small-angle X-ray scattering (SAXS) or Fourier Transform Infrared Spectroscopy (FTIR) years. A confirmation of interaction between heating temperature and exposure to the bone and its effect on the size of crystallite has been done. Comes next by is a different type of study involving the micro structural analysis of bone will suggested that the size of osteon decreases with increase in the temperature however it was contradicted by a similar kind of study. Inclusive of the same it can be seen that bone microstructures can be used to estimate age even at temperature as high as 600° C-900°C.

The studies involving histomorphological research, CI index, structural analysis of hydroxyapatite crystals and more showed a varied methods of standards which resulted in no one particular base study for coming up research and the method of experimentation. These categories of microscopic alteration were furthered by described four stages of thermal decomposition. These groupings shared several parallels with other categorisation system, which is attributed to their comparable sampling methods and experimental design. Gave a solution for the problem by conducting a research with an application of quantitative petrography by creating thin section of modern animal bone by using the method of creating a sample by applying a combination of Epoxy Resin RX77IC/NC and HY951 Hardener at a ratio of 10:1. It proves to be better can creating microtome but turned out to be time consuming. This article has also proposed a new quantitative method to determine burning intensity based on the quantification of H-I changes in burned bone. The use of the PETROG software proved to be reliable and quick when analysing samples.

A significant study conducted Shows how the modern day analysis method of x ray and micro CT scan proving to be an asset in forensic anthropology. The research was conducted on bones of different animals majoring the effect of a range of temperature on the parameters like Micro CT analysis of the diaphysis of the roe deer phalanges were distinguished from the proximal and distal epiphyses, and the following parameters were measured: bone volume; volume of the voids within the diaphysis; and volume of the marrow cavity. The results showed present a rich discussion of the biomechanics of burned bone and promote seven classes of fractures, including longitudinal, step, transverse, patina, splintering and delaminating, burn lines, and curved transverse. Chi-square results find a significant difference between charred and organically stained bone (d f=1, χ 2=23.46) and charred and calcined bone (d f=1, χ 2=5.76)..

Traumatic fractures can also be an important identifying feature of burned bones. With most common types of longitudinal and transverse fracture there as fractures which are specific to burned bones, namely curved fractures. These fractures are most commonly observed on diaphysis, specifically more closure to epiphysis. They are also dictated by patterned progression of soft tissue loss during heating. Another unique fracture is found at the location of patina, patina is only found where thin cortical bone overlay trabeculae. The fractures are in series of intersecting irregular line. More recently it has been noted that factors like potential influence of blood, marrow, moisture, and fat in specimens on heating conditions affect the observable features of burned bones. It is also suggested the flame temperature conditions of a natural environment for the study.

Another approach of modern techniques of investigation was done who attempted human albumin detection by immunological methods in 31 archaeological cremations. He suggested that albumin can survive cremation about 300°C after a thorough study with a success rate of 26%, later in recent studies he successfully detected protein detection in burned remains with temperature range of 800°C to 1200°C .

More suggestion of method to identify burned bones includes parameter of bone mineral crystal analysis. This parameter can show interspecies variations and can be used to detect human from non-human bones through X ray diffraction analysis. Interestingly isotope analysis can provide an important prospective to identification of

burned bones and for ontological profiling. The isotopes of carbon(C), nitrogen (N), oxygen (O) and strontium (Sr) gives clue about geographical location and migrant movement of the subject. Later adding more this structural carbonate can also be used to date burned bones through AMS dating technique. The successes of these processes are influenced by temperature and re-crystallisation of mineral.

Supported the previous studies with also displaying numerous results between the burning of greasy and non-greasy bones. Used the application of Neutron spectroscopy technique with the detector of FTIR, in which they estimated the OH bond vibration at specific temperature. Through this technique we can differentiate a burned bone and a fossiled bone. The author wants to increase the scope of the study to determine the different temperature of burned bones.

Recovery

The haphazard and without any standard operating procedure the lack of recovery protocols are proving to be a great setback for forensic investigation of burned bones or fatal fire scene. Based on the burned trauma there can be three factors in diagnostics of recovery, namely: body position and tissue shielding, colour change and burned bone fracture biomechanics.

The extrinsic factors in burn trauma vary from one situation to another. Describe the three reliable factors in the diagnostic process of recovery: body position and tissue shielding; Colour changes; and burned bone fracture biomechanics.

Based the issue an important study conducted by(Siegert, Hamilton, Erhart, & Devlin, 2020) to figure out the most suitable consolidant. The study conducted with bone samples including femora and skull of domestic pig, burned with no accelerant and allowed to extinguish naturally. Following, AcryloidTM B-72, AcrysolTM WS-24, RhoplexTM B-60A, and Butvar1 B-98 solutions consolidant were tested with different testing parameters of mechanical testing namely: Nanoindentation, Drop weight impact test and Forced vibration test. AcryloidTM B-72 proves to be the most suitable consolidant.

Discussion and Conclusion

The applications of forensic anthropology in crime scene investigation are proving to be of outmost importance when it narrows down to burned bone evidences. Various scenarios of house fire, motor vehicle accidents, deliberate burning of evidences, open, burning the body after murder, suicide and similar cases.

The anthropological analysis of burned bones provide a range of biological profiling methods, such as age estimation, sex, trauma and perimortem (other than thermal analysis), antemortam and postmortem analysis and important race estimation tool but fails in terms of stature estimation due to the fragility of the burned bones.

It is in our benefit to understand the different scenarios of temperature effect on burned bones; there can be different factors which can influence the temperature like, time duration, material involved, environmental conditions. Although numerous researches have been conducted on burned bone as important anthropological evidence, there are a number of voids to be filled still. The different studies suggested the range of temperature and its effect on the burned bones, but the standard is still remains missing. While the search has shown positive outcomes of analysis of burned bones for forensic anthropologist further research needs to be done on the standardisation of these data for a better investigation.

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