Forensic Science International 275 (2017) 260–271

Contents lists available at ScienceDirect

Forensic Science International

journal homepage: www.elsevier.com/locate/forsciint

Sharp and blunt force trauma concealment by thermal alteration in homicides: An in-vitro experiment for methodology and protocol development in forensic anthropological analysis of burnt bones

Ioana Macoveciuc[a,b], Nicholas Márquez-Grant[a,*], Ian Horsfall[c], Peter Zioupos[d]

[a] Forensic Anthropology Group, Cranfield Forensic Institute, Cranfield University, Defence Academy of the United Kingdom, Shrivenham, SN6 8LA, United Kingdom
[b] Security and Crime Science Dept, University College London, London, WC1E 6BT, United Kingdom
[c] Impact & Armour Group, Centre for Defence Engineering, Cranfield University, Defence Academy of the United Kingdom, Shrivenham, SN6 8LA, United Kingdom
[d] Musculoskeletal & Medicolegal Research Group, Cranfield Forensic Institute, Cranfield University, Defence Academy of the United Kingdom, SN6 8LA, United Kingdom

ARTICLE INFO

Article history:
Received 19 April 2016
Received in revised form 16 January 2017
Accepted 20 March 2017
Available online 29 March 2017

Keywords:
Forensic anthropology
Human remains
Burning
Sharp force trauma
Blunt force trauma
Homicide

ABSTRACT

Burning of human remains is one method used by perpetrators to conceal fatal trauma and expert opinions regarding the degree of skeletal evidence concealment are often disparate. This experiment aimed to reduce this incongruence in forensic anthropological interpretation of burned human remains and implicitly contribute to the development of research methodologies sufficiently robust to withstand forensic scrutiny in the courtroom. We have tested the influence of thermal alteration on pre-existing sharp and blunt trauma on twenty juvenile sheep radii in the laboratory using an automated impact testing system and an electric furnace. The testing conditions simulated a worst-case scenario where remains with pre-existing sharp or blunt trauma were exposed to burning with an intentional vehicular fire scenario in mind. All impact parameters as well as the burning conditions were based on those most commonly encountered in forensic cases and maintained constant throughout the experiment. The results have shown that signatures associated with sharp and blunt force trauma were not masked by heat exposure and highlights the potential for future standardization of fracture analysis in burned bone. Our results further emphasize the recommendation given by other experts on handling, processing and recording burned remains at the crime scene and mortuary.

1. Introduction

Deaths from sharp and blunt force trauma are common in homicide cases [1–5], particularly in countries where civilian use of firearms is strictly regulated. In England and Wales for instance, 2011–12 homicide data shows that out of 550 homicides, 200 resulted from sharp instruments and more than 100 from blunt trauma [6]. Homicides, whether by sharp, blunt or other type of trauma, are often concealed through burning [7]. In such circumstances, where expertise in burn patterns and differential bone fracture propagation is required, the presence of the forensic anthropologist is advisable [8–11]. Currently, this expertise mainly relies on experimental research investigating perimortem trauma in the absence of thermal alteration or vice versa and forensic casework experience.

In the literature, cremated bone has been examined macroscopically, especially with regard to methods for biological profile estimation [12,13]. Microscopically, bone structure and compositional changes have also been investigated at length [14,15] using specialized analytical techniques such as X-ray diffraction and/or X-ray spectroscopy [16,17], Scanning Electron Microscopy [18,19], Transmission Electron Microscopy [20] and Fourier Transform Infrared [21,22]. In contrast, investigations of full-body burn patterns [23–25] and effects of flesh combustibility [26,27] are scarce, with a limited number of studies analysing remains from crematoria [28,29]; these aspects have been addressed secondarily to, for instance, analysis and weighing of cremated remains for identification [30,31]. With respect to mechanical trauma, blunt

* Corresponding author at: Cranfield Forensic Institute, Cranfield University, Defence Academy of the United Kingdom, Shrivenham, SN6 8LA, United Kingdom.
E-mail addresses: ioana.macoveciuc.16@ucl.ac.uk (I. Macoveciuc), n.marquezgrant@cranfield.ac.uk (N. Márquez-Grant), i.horsfall@cranfield.ac.uk (I. Horsfall), p.zioupos@cranfield.ac.uk (P. Zioupos).

http://dx.doi.org/10.1016/j.forsciint.2017.03.014
0379-0738/

trauma research has been extensive, with studies from both clinical and forensic perspectives. Although these mainly focus on head trauma [32,33] and associated computerized models [34,35], they also include analysis of fractures associated with child abuse [36,37], fracture toughness in long bones [38] and autopsy case reports of various accident types [39,40]. Similarly, sharp force trauma has also been thoroughly investigated, with studies addressing stabbing events [41,42], cut marks, weapon edge striations analysis and metal residues at impact sites using microscopic techniques [43–45] and knife blade [46] and screwdriver tip morphology [47] at macroscopic level. However, experimental research combining both perimortem trauma and thermal alteration is scarce [11,28,48–50], the majority with inadequately controlled testing environments and unevenly distributed sample sizes and demographics.

In light of the current literature, we hypothesized that 'fresh' bone trauma morphology and any associated fracturing, although exacerbated by heat, will still be distinguishable from damage produced by thermal alteration due to differential failure mechanism of bone. Juvenile sheep radii were used in the simulation of a closed-compartment fire [18,50,51] in which calcined human remains recovered presented either sharp or blunt trauma in addition to various types of defects and fractures due to burning. The current sharp trauma experiment simulated a typical cutting action impact produced by a large knife; whilst the blunt trauma experiment simulated a baseball bat impact [33,42]. The methodology was repeatable whereby equipment which allowed proper regulation of the scenario was utilized. Biomechanically, control of the nature of impact during experimentation is of high importance for an understanding of how and why bone behaves in a particular manner during loading.

The principal objectives of this controlled experiment are: to demonstrate that field experiments can be replicated in a realistic manner in the laboratory and that the variation in the observed thermal defects can be reduced to factors which are pertinent to the variables being tested rather than to factors which cannot be fully controlled in a field experiment. Hence, the main aim is to resolve discrepancies amongst experimental approaches which deter adequate comparison of data sets and which are the cause for current divergence in expert opinion by investigating which types of heat fractures occur and whether this is dependent on the presence of mechanical trauma. This approach also seeks to promote future drafting of experimental protocols sufficiently robust to withstand forensic scrutiny, thereby solidifying forensic anthropological expert opinion in the courtroom.

2. Materials and methods

2.1. Samples

Twenty fresh juvenile sheep radii under three years of age (verified by the degree of epiphyseal fusion [52]) were purchased from a local abattoir (the sheep were slaughtered on the day the purchase was made). The samples were allocated as follows: two samples for determining optimal experimental conditions, 14 for the applied mechanical trauma and four as controls; the latter group were thermally altered intact and in the absence of previously applied trauma. Specimens were kept in a laboratory freezer and subsequently removed and refrigerated at 4 °C for two days for gradual defrosting in advance of the experiment. After defrosting, larger muscle layers were removed using a dissection scalpel and each specimen was photographed and measured.

Sheep was preferred because its frequent use in the literature allowed comparison with other studies [53,54]. Defleshing was carried out because fat, muscle and skin act as fuel themselves [26] and will affect the temperature at, which the bone is burnt. Since their proportions can vary between individuals, removing the soft tissue ensured greater temperature uniformity across all specimens.

2.2. Mechanical trauma

Trauma was dynamically applied using an IMATEK Impact Testing System (Imatek® Ltd, Old Knebworth, Herts, SG3 6QJ, UK) equipped with a sensor to control and record load, time, energy dissipation and an experimental chamber within which the test rig and samples were mounted. Fourteen samples were used, seven for the sharp trauma (SFT 1–7) and seven for the blunt trauma experiments (BFT 1–7). The specimens were wrapped in commercially available cling film to ensure stability during impact and prevent the loss of bone fragments (if produced).

The sharp trauma scenario replicated a cutting action with a large knife, using a striker measuring 2.2 × 0.01 cm (Fig. 1) at a velocity of 4.0 m/s and a total impact mass of 3.703 kg. This corresponded to impact energy of approximately 28 J and a peak force of 3.2–4.0 kN. The blunt trauma experiment simulated a baseball bat impact using a 15 cm long and cylindrical impactor (Fig. 2) at a velocity of 6.0 m/s and total impact mass of 4.102 kg; corresponding to approximately 84 J and a peak force of 5.6–7.7 kN.

Each specimen was placed onto three non-deformable sponges, with each epiphysis further secured with plastic tape (Figs. 3 and 4). This ensured that the impactor would always come into contact with the midsection of the anterior surface of the bone shaft, perpendicularly to the long axis of the bone. The purpose was to isolate impact forces to compression and tension and maintain impact angle constant to reduce variability in the resulting defects [55–57]. The correlation between impact generated by the testing system and impact generated by a manually-handled object is as follows: the impact velocity originates from the generated momentum during the hitting action whilst the impact mass is a combination of the actual mass of the object and that originating from the body of the attacker; together, these generate the impact force to which the sample is subjected.

Fig. 1. Anterior view of the sharp impactor.