AN INVESTIGATION INTO IDENTIFYING SHARP FORCE TRAUMA ON BURNED BONES

THESIS

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CHAPTER I

INTRODUCTION

Recent advances in forensic anthropology have greatly increased an investigator's ability to piece together an often complicated crime scene. In particular, research has been conducted on various aspects of sharp force trauma to the human skeleton (Humphrey and Hutchinson 2001, Maples and Walsh-Haney 1999, Purdue 2000, Symes, et al. 1998, Symes, et al. 2002). While other studies have focused on the effects of fire on human remains (Correia 1997, Dirkmaat 2002, Glassman and Crow 1996, Norlander 1995, and Redsicker 2003). However, only a couple of studies have examined the combined effects of fire and sharp force trauma on bone (de Gruchy and Rogers 2002, Smith and Pope 2003, 2004). These studies have all used either liquid accelerants combined with wood, or wood burning fires with no other accelerants as a fuel source. These studies have also been limited by using only one or two sharp instruments during the experiment, and a priori knowledge that all of the remains had sharp force trauma present.

Fire and Sharp Force Trauma: A Review of the Literature

Introduction

Forensic anthropologists are often called upon by law enforcement officers to assist in analyzing various forms of antemortem, perimortem, and postmortem trauma on human bones. Of special interest is evidence that will provide information regarding possible manner of death. However, when dealing with suspicious deaths, information relevant to a positive identification and manner of death are often obscured by combining perimortem or postmortem activities. It is critical that forensic anthropologist be able to distinguish between perimortem and postmortem trauma. To do so, the anthropologist must have knowledge of bone structure properties, extensive training, and experimental confirmation in the analysis and interpretation of trauma to the human skeleton.

The accuracy of interpretation is crucial, and it can be complicated by multiple activities occurring after death. Burning is often a deliberate attempt to obscure sharp force trauma and victim identification. The problem is simple. Fire causes trauma to bones by splitting, cracking, and breaking; and sharp force trauma also can cause splitting, cracking, and breaking. However, experiments have successfully demonstrated that fire induced trauma may be distinguished from sharp force trauma (de Gruchy and Rogers 2002, Pope and Smith 2003, Herrmann and Bennett 1999).

Burning

The progression of fire is initially governed by fuel supply, oxygen, and a heat source. However, as the fire moves from the point of origin it will follow the path of least resistance that will often transcend four predictable phases (Redsicker 2003).

Phase I: The incipient phase is the first to occur, and varies in longevity depending on fuel.

Phase II: This entails emergent smoldering along with some combustion.

Phase III: The free burning phase is characterized by the increased rate of intensity in open burning. In other words, as heat increases in the presence of abundant fuel and oxygen, the fire will burn freely.

Phase IV: If the open burning of Phase III is restricted by lack of oxygen such as in a closed container, the oxygen-regulated phase is reached.

Recovery

The recovery process is extremely complex in fire investigations and great care must be given to locating evidence including human remains. It is common for remains to be missed when they are collected by individuals untrained in recovery techniques (Dirkmaat 2002). For example, while some fire investigators may find raking the remains into a bag an efficient means for collection, this should is unacceptable when human remains are present. The presence of the forensic anthropologist at the crime scene is crucial to the interpretation of the skeletal remains. Depending on the particulars of the case, this information may include: (1) location and orientation of the body, (2) accurate identification and collection of the human remains, (3) field identification and observation of precremation trauma, and (4) possible evidence that may indicate the intensity and duration of the fire (Dirkmaat and Adovasio 1997).

Recovery of complete skeletons is often impossible due to the destructive nature of the fire. Sometimes remains are lost within the matrix of various amounts of burned debris masking their identification (Owsley, et. al 1995). Other times, fragmented remains may be carried away by environmental influences (Glassman 2003). Fingers and toes are frequently not recovered due to their size and becoming hidden in the ash below the body. In general, these small bones are often not completely burned away as some have previously thought (Pope and Smith 2004).

Analysis and Description

Following recovery, the forensic anthropologist enters into the analysis stage of the investigation. When fire is involved, the two biggest variables that affect the condition of the remains are intensity and duration of the heat. Accelerants, surrounding chemicals, insulators, oxygen levels, and location all play a role in the process of destruction (Norrlander 1995).

While not destroyed, the fire can greatly alter the structural integrity and physical appearance of bone. For example, when a forelimb is exposed to intense heat the outer layer of skin becomes dehydrated, changes color, and splits. The initial blistering occurs quickly in the early stages, and is explained as chemical damage of skin layers at the dermal-epidermal junction (Pope and Smith 2004). This damage exposes underlying fat and muscles that will recede and burn away. Finally, the bone is directly exposed to the fire. When bone is exposed to intense heat from fire, it will become less elastic as the collagen dehydrates. This dehydration increases as the organic material is destroyed. This action results in a reduction in size, distortion, and often fragmentation of bone (Smith and Pope 2003). Once these changes have occurred, it is essential to record them in a cohesive and efficient manner.

A model has been proposed by Glassman and Crow (1996) to help standardize the process of recording. They used a five level model to describe various degrees of bony injury from fire.

Level #1: The body is typically recognizable, and often includes some blistering and singeing.

Level #2: Is characterized by varying degrees of charring, and additional searching is often needed to collect disarticulated elements.

Level #3: Major portions of the head and/or arms are missing, and the head is usually unrecognizable.

Level #4: Extensive destruction and the skull is fragmented. At this level of destruction, search and recovery should include screening to locate small bones and dental fragments. The arms and/or legs may still remain articulated to the body.

Level #5: Cremated, fragmentary, and with little or no tissue present.

Shipman, et al (1984) have also developed a five stage description, but theirs is concerned with the color of bone. These color changes are divided by the temperature the bone was exposed to, ranging from 20º to 940º C.

Stage I (20-285º C): The bone stays a neutral white, pale yellow, and yellow.

Stage II (285-525º C): Colors of bone range from reddish brown, dark grey-brown, neutral dark-grey, and reddish yellow.

Stage III (525-645º C): Bone is described as neutral black, medium blue, but with the appearance of some reddish yellow.

Stage IV (645-940º C): Marked by predominately neutral white, with some light blue-grey and light grey noted as well.

Stage V (940º C plus): The bones appear neutral white and observable medium grey and reddish-yellow (Shipman et, al 1984).

However as Shipman, et al (1984) noted from these studies, that color alone cannot be used to determine the precise temperature at which the remains were exposed. Only a general range can be deduced from color alone. This has been supported in more recent experimentation by Pope and Smith (2004), in which they found color to represent a mixture of temperature, time exposed, and the destruction level of organic material.

Other factors may influence color as well, especially in a crime scene where multiple variables are present. Different organic materials on or around the fire often influence the coloration of the remains. For example, brown has been associated with hemoglobin or soil discoloration and black from carbonization in oxygen starved environments (Correia 1997). Colors such as green, yellow, pink, and red have been attributed to the presence of copper, bronze, or iron surrounding the remains. These different variables may be responsible for multiple color changes on the same area of bone. Thus, the interpretation of the color of burnt bones should consider all other factors present at the scene.

Correia (1997) has noted that when exposed to temperatures higher than 800º C bones undergo shrinkage and deformation. The destruction by shrinkage from extremely high temperatures may impair forensic anthropologists' ability to estimate sex, age, ancestry, and stature. Although, most evidence to date has suggested that bone exposed to temperatures less than 800º C do not shrink enough to impair interpretation. However, deformation of bone may still be quite severe even when shrinkage is not, and the bone will fracture at its mechanical failure point (Correia 1997).

At advanced stages of burning all organic material is lost, causing bone to fracture (Herrmann and Bennett 1999). Fracture patterns as a result from exposure to heat are a crucial aspect to any fire investigation. A forensic anthropologist must attempt to distinguish between preexisting fractures and heat induced fractures that were created postmortem. Fractures caused by heat exposure are generally described and defined by their location and direction. The heat-induced fractures that occur to long bones include longitudinal, curved transverse, straight transverse, patina, and delamination. In particular the curved transverse fractures have been commonly referred to as thumbnail fractures, and do not reflect any traumatic fractures making them unique to heat exposure (Herrmann and Bennett 1999). Longitudinal fractures extend down the long axis, with an occasional twist. Straight transverse fractures are often seen at one end of a longitudinal fracture, or as short lines around the circumference of the bone. Patina fractures usually occur at the epiphyses, and have been described as resembling old paint on an oil canvass (de Gruchy and Rogers 2002, Hermann and Bennett 1999). Finally, delamination fractures happen when cancellous bone separates from cortical bone. These fracture patterns of burned bone do not extend into fresh, unburned bone. Therefore, the presence of a fracture in unburned regions would be antemortem (Pope and Smith 2003).

Sharp Force Trauma

Defects on bone caused by sharp force trauma from common household items such as a knife, saw, or sharp kitchen tool is a frequent occurrence in many homicide investigations. The ability of the forensic anthropologist to accurately identify and interpret sharp force trauma on skeletal remains may be very important in law enforcement investigations.

Analysis and Description

Sharp objects are variable in their length, width, number of teeth (if any), and mode of use (saw, stab, chop, hack), making it very difficult to catalogue specific detailed characteristics regarding every sharp object. However, gross characteristics of cut marks on bone are associated with some sharp objects (Symes et al. 1998). For example in sharp force trauma produced by a knife, the characteristics include a narrow blade, V-shaped cross section, smooth striations, striations perpendicular to the kerf floor (the groove made by a knife), and minimal wastage. When looking at saw marks, the blade dimensions are wider, the cross section is square, there are often visible striations, the striations are parallel to the kerf floor, and there is moderate wastage. Sharp force trauma from a larger blade such as an axe tend to be very wide, V-shaped in cross section, with smooth or microscopic striations that are perpendicular to kerf floor, and there is often significant wastage. In cases when an axe was used on the skull, the axe commonly produced trench-like fractures with comminuted margins. With repeated blows the cranium may fragment completely with panmeningeal hemorrhage. This type of sharp force trauma is often mistaken by the untrained observer as ballistic trauma (Purdue 2000).

Interpretation

The examination by the forensic anthropologist should include a consideration of the minimum number of stabs or cuts, characteristics of the weapon, depth of penetration to the bone, direction of thrust, force required, and the effects of such an injury (Steadman 2003, Purdue 2000). This information is not always easily obtained from the bones. For example, trauma is not always found in the most obvious places, and sharp force trauma is often associated with violent and frantic activities. However, when the location of sharp force trauma is found on the arm, wrist and hand, this may indicate defensive wounds that occurred during the perimortem period. If the victim tries to defend him or herself by warding off blows with the forearm or grasping the weapon with the hands, multiple wounds may then be found (Gordon, et al. 1988, Knight 1997).

Careful attention and description of each cut mark is necessary to extract as much the information as possible. For example, marks left by a serrated knife used as a saw will show only one inside wall of the cut as smooth and polished, while the other will be striated (Reichs 1998). False starts have proven to be one of the best indicators of saw tooth shape and size because they tend to be clustered, and do not sever the bone (Symes, et al., 1998). False starts are also good indicators of which side the trauma started on a bone that has been completely severed. Since false starts are of such value to a forensic anthropology investigation, samples of bone taken during autopsy are removed to preserve this evidence. Also, labels indicating cuts made during autopsy should be provided to avoid confusion (Symes, *et al.*, 1998).

Dealing with mutilation by sharp force trauma, interpretation can become complicated. For example, more than one tool may be used during the commission of a homicide. In one extreme example, it was concluded that the victim experienced perimortem injuries of blunt trauma to the right side of the cranium, deep sharp force trauma on the mandible, and sharp force trauma on the vertebrae. Each of the alterations was made by different tools (Ubelaker and Smialek 2003).

Taphonomic processes also need to be taken into consideration, especially when comparing perimortem trauma and postmortem scavenging. White (2000) has identified some differences between these two variables. A cut mark will usually be much narrower, finer, and more V-shaped than carnivore activity that occurred during the postmortem interval. Carnivore activity tends to be a single rough furrow, and rodent activity is typically described as a flat-bottomed trough.

Identifying Sharp Force Trauma on Burned Remains

In order to confirm or deny interpretation of perimortem defects, it is often necessary to conduct experimental research under controlled settings. This allows for testing hypotheses and measuring probable rates of accuracy in interpretations made during actual forensic casework. Prior experiments have been conducted to examine sharp force trauma on burned bone. Herrmann and Bennett (1999) concluded that sharp force trauma was not readily recognized after incineration. However, saw cuts and saw kerf walls were detectable on the burnt remains, and knife marks were also recognizable after burning. Heat induced fractures that traversed some of the more superficial cuts made identification of sharp force trauma difficult. Although on the deeper cuts it did not appear that they influenced the direction of fracture propagation during burning. This experiment took place in a closed structure, and used the femora of domestic pigs (*Sus scrofa*). The bones were burned in wood fires and no artificial accelerants were used.

Another study employed domestic pig forelimbs and cow ribs to evaluate the effects of burning on identification of trauma caused by a common hatchet (de Gruchy and Rogers 2002). An outdoor fire was used to simulate a cremation in a forensic context, and the fire was tended and agitated for three hours. The chop marks were easily identified. No liquid accelerants or any other sharp instruments besides the hatchet were used in this experiment, and the wood material consisted of cherry, cedar, and small cedar shrubs. The marks were identified using the naked eye and a 1.6x microscope. The chop marks were basically unaffected by burning, except for shrinkage that reduced the overall size of the marks.

Finally, Pope and Smith (2003) looked at sharp force trauma on human skulls and the effects that burning had on identification of that trauma. Trauma included superficial scalpel incisions, deep knife wounds, and saw marks on the skulls. Pyrometric thermocouples were applied to measure the temperatures that ranged from 400º F to 1600º F and observations were made with the naked eye and 10x-40x microscope. Pope and Smith were able to microscopically recognize and distinguish between the preexisting trauma and heat induced fractures that were present. They were unable to reproduce sharp force trauma to the bones after they had been burned. This helps to eliminate the possibility of damage during recovery being mistaken for perimortem trauma.

These experiments were each successful in that the investigators were able to identify the sharp force trauma after the remains were burned. However, in each analysis, blind tests were not conducted, and the investigators already knew which tools were used on each bone. During a forensic investigation the anthropologist does not know a priori which bones, if any, have been subjected to sharp force trauma. By already knowing which type of tool was used on each bone, the observers may have been biased in identifying the sharp force trauma. In each experiment, remains where burned without the use of liquid accelerants such as gasoline or diesel. When added to the fires these fuels may further damage the remains, therefore complicating the identification of sharp force trauma. A blind test would require the anthropologist to analyze remains without knowing if they had been subjected to sharp force trauma or not, what kind of instrument may have been used, or what kind of accelerant may have been present. Such a test would better simulate the condition of true forensic investigations.

Conclusion

The role of the forensic anthropologist has become vital to fire investigations that involve human remains. The forensic anthropologist is an integral part of an investigation team that include forensic pathologists, odontologists, fire investigators, paramedics, and various other professionals who may be involved in the case. Each plays a role in the interpretation of all sorts of material that have been exposed to highly destructive forces. It is likely that the forensic anthropologist will be asked to assist in interpreting skeletal defects that may have been caused by such forces as heat exposure and/or trauma to bones. To successfully complete this task, the anthropologist must be familiar with the various effects that fire has on human remains, as well as knowledge of fracture patterns and cut-mark morphology indicative of trauma.

The Investigation

This study investigates the effects that liquid accelerant-only fires have on the identification of pre-existing sharp force trauma to the radius, ulna, carpals, and metacarpals. Wounds to these bones are commonly called defense wounds because they are created when victims try to defend themselves from a sharp instrument attack. Being able to identify sharp force trauma to this area of the forelimb provides investigators with evidence of a possible homicide. Unfortunately, there are times in which bone remains are fragmentary, which can obscure cut mark defects. This is possible in deaths that involve a fire context, since cremation processes are known to distort and fragment bone. This study tests the hypothesis that various forms of sharp force trauma produced on fresh bone and then subjected to fire will still retain identifiable cut morphology that can be used to differentiate the sharp force trauma from the fragmentation effect of the fire. Included in this study are several variables not used in previous experiments, making this investigation a unique approach to the problem if identification of sharp force trauma. These variables included multiple types of instruments, uncut remains used as study controls, outside observers for conducting blind testing, and use of a variety of different liquid accelerants.

CHAPTER II

METHODS AND MATERIALS

The experimental design used the distal half of pig (*Sus scrofa*) forelimbs to simulate human forearms. The limbs were acquired with the soft tissue still intact. In other words, there were no alterations to the limb to more closely approximate the fresh tissue state of a human inflicted during an attack. Pigs were selected as the model of human biology for two primary reasons. First, they were easily accessible, as opposed to the difficulty of accumulating a large number of cadaver limbs, and second, pig soft tissue has been preferred in many investigations due the similarity in properties of pig and human skin (Vana and Meingassner 2000), thus the burning more closely resembles the burning of human remains.

Five different instruments were used to produce the sharp force trauma. The five instruments include a meat cleaver, an ice pick, a common straight edged kitchen knife, a machete, and a serrated steak knife. These five tools were selected because they are common place in many homes, and therefore are common weapons of opportunity. The limbs were placed on an asphalt pad and then subjected to stabbing and hacking. One instrument was used per limb, to exclude the possibility of multiple injuries from different weapons. The meat cleaver and machete were used in a hacking manner, while the ice pick, straight edge knife, and serrated knife where all used in a stabbing motion.

After five limbs were cut with a different instrument, they were placed together on a metal grate inside a large metal pan along with one uncut limb as a control. Subsequently, one gallon of a liquid accelerant was poured on top of all the limbs and into the pan. Only one accelerant was used at a time, and there was no mixing of liquids. The pan was then placed outdoors on an asphalt pad, and away from any structures or vegetation to prevent the possibility of other variables affecting the heat of the fire. The fire was started, allowed to burn until the liquid accelerant was completely consumed, and the fire was completely out. During the progression of the fire, the limbs were each rotated 90 degrees left after the first 30 minutes of burning, then another 90 degrees left at the one hour mark. This would ensure maximum exposure of the fire to all areas of the limb. This procedure was repeated four times with four different accelerants. The accelerants included 87 octane unleaded gasoline, diesel, kerosene, and turpentine.

After burning, the remains were left in the metal pan to cool. Since all remains were kept in the pan, the post-fire collection consisted of bringing the pan inside the Human Skeletal Identification Laboratory at Texas State University-San Marcos. There, each set of remains were placed on a table, and labeled with the particular accelerant and tool used. This process was repeated four times representing each type of accelerant. With six limbs being used for each of the four accelerant burning episodes, a total sample size of 24 limbs was used in the experiment.

After all 24 limbs (cut and uncut) had been burned; they were given non-sequential seven digit catalog numbers. Each limb was placed into a separate brown paper bag, with the catalog number written across the side of the bag. The bags were then stored in cardboard boxes for three months. The details of which bone was in any bag remained unknown to myself and the invited researchers who would be asked to analyze and interpret each set of remains.

The analysis phase consisted of my attempt to identify sharp force trauma (if any) on the remains without knowing which tool was used. The attempt to identify injuries was done at the macroscopic level. If no trauma was found, the remains were recorded as uncut. However, if evidence of sharp force trauma was found, an attempt was be made to correctly identify which particular tool was employed.

The remains were then analyzed by three individuals from the University of Texas in Austin. These three outside observers formed the blind test portion of the project. In previous studies of fire and sharp force trauma (de Gruchy and Rogers 2002, Smith and Pope 2003, 2004) the researchers knew all the remains had been subjected to sharp force trauma, and knew which types of instruments were used to create the sharp force trauma. The three outside observers in this study were only told that the remains were burned, and were asked to look for any evidence of sharp force trauma. They were asked to identify any evidence they observed and to interpret their findings. Their data was then compared to the data recorded during my analysis of the remains.

While the destructive force of fire does often produce fractures, it has been demonstrated that defects caused by the sharp force trauma would still be identifiable after the fire. This experiment, then, is a test of the ability of forensic anthropologists to locate possible sharp force trauma on human remains in cases that involve fire.

Observations of Cutting and Burning

The following observations were made during the cutting and burning portion of this experiment. Before burning five limbs were set on the asphalt, and each limb was were stabbed and hacked with one of five different instruments. A sixth limb was included as the uncut control. The limbs were placed on top of a metal grate that was set into a metal pan approximately three inches deep, and one of the accelerants was poured over the limbs. The weather was recorded during each day of burning. This was done to account for possible differences between each fire that may have been the result of variables other than fuel type, such as wind direction and speed.

08-08-04 Burning with Unleaded Gasoline

Weather: 90 ºF, sun was visible, cloudless, and windless.

At approximately 12:05pm all six limbs were soaked with unleaded 87 octane gasoline. All excess fuel collected at the bottom and eventually rose to the level of the grate where the remains were suspended. Approximately one gallon of gasoline was used. The limbs were then set on fire.

At 12:10 p.m., the limbs had turned black on the top and sides, and the entire metal pan was engulfed in flames. At 12:35 p.m., the limbs were still completely engulfed in flames, but were then turned 90 degrees to the left. As this was done, the flames became more intense on the underside of the limbs that were now exposed to open flames. This area was not yet completely blackened as the other sides were. Also, grease could be seen dripping from the open wounds on the limbs. At 1:05 p.m., the remains were turned another 90 degrees left, so they were now 180 degrees from the original starting position. This was done to ensure all areas of the limbs were equally exposed to the fire. While all areas of the metal pan still had flames present, the fire was rapidly dying out. At 1:08 p.m., the fire was almost completely dead, with only a few flames remaining. At 1:11 p.m., the fire had completely died out. At 1:35 p.m., the metal pan had cooled enough to touch, and the remains were brought back into the laboratory.

08-25-04 Burning with Kerosene

Weather: 94º, sunny, cloudless, steady winds from the West.

At 11:30 a.m., the six pig forelimbs were set on fire with approximately one gallon of kerosene. At 11:45 a.m., all six limbs had turned solid black on the top and sides of the limb. The condition of the underside of the limb was not known. All limbs had flames engulfing them.

At 11:47 a.m., grease could be observed boiling out of the forelimbs that were subjected to sharp force trauma. No grease was observed coming out of the uncut limb. The grease from the limbs cut by the cleaver, machete, and both knives was slowly dripping out; however, the grease was projected out of the openings created by the ice pick. At 12:00 p.m., all six limbs were turned 90 degrees left, at which time even more grease could be seen dripping and boiling out. At 12:06 p.m., all limbs were observed to be continuously releasing boiling grease from various parts of the limb, not just areas exposed to sharp force trauma.

At 12:14 p.m., the distal and proximal end of each limb had turned grey and white in color. At 12:30 p.m., all six limbs were turned another 90 degrees left, to ensure exposure to all areas. More grease could be seen boiling out of the limbs as they were being turned. At 12:36 p.m., not much kerosene remained, but the fire was still burning consistently on all limbs. At 12:43 p.m., the fire was steadily dying out on all limbs. At 12:54 p.m., the fire had completely died out.

09-03-04 Burning with Diesel

Weather: 90º, sunny, partly cloudy, no wind

At 3:10 p.m., the limbs were set on fire in a metal tray with approximately one gallon of diesel fuel.
At 3:22 p.m., the tops and sides of all limbs had turned black. At 3:31 p.m., grease was boiling out of the areas exposed by sharp force trauma. The machete and cleaver wounds were releasing more grease than the ice pick, serrated steak knife, and the kitchen knife wounds. No grease was observed boiling out of the uncut limb. At 3:40 p.m., all limbs were turned 90 degrees left. As they were turned, additional grease was observed boiling out of the exposed areas of the limbs. At 3:52 p.m., the distal and proximal ends had turned grey and white; however, less of the area had changed color than was observed during the kerosene burning. At 4:10 p.m., all limbs were turned another 90 degrees to the left to ensure all areas of the limbs were exposed to the fire. Additional grease was seen boiling and pouring out of the limbs, especially near the midshaft where the sharp force trauma was concentrated.
At 4:28 p.m., the fire was slowly dying out. At 4:32 p.m., the diesel has been almost completely consumed, and the fire was present only sporadically in a few areas of the metal tray. At 4:37 p.m., the fire had completely died out.

09-25-04 Burning with Turpentine

Weather: 82º, cloudy, wind from the west.

All limbs were cut in the same manner as the previous burnings. However, during the stabbing of one limb with an ice pick, the tool became stuck between the radius and ulna. The ice pick could not be removed, and remained in place during the burning.

At 4:50 p.m., all limbs were set on fire in the metal tray with approximately one gallon of turpentine. The fire initially appeared to have significantly more smoke released into the air than from fires of the previous fuels. The flames also appear to be more intense and reached higher into the air than the previous fires. At 4:54 p.m., the tissue turned black on the top and sides of the limbs. At 5:00 p.m., just as in the previous fires, grease was observed boiling out of wounded areas of the limbs. However, grease was not projecting from the ice pick wounds as in previous burnings. The reason for this difference may have to do with the ice pick remaining inside the limb (See Fig. XXIX)

CHAPTER III

ANALYSIS

As stated previously, each limb was placed into a brown paper bag, and given a seven digit non-sequential number. The number, type of fuel, and the sharp instrument used were recorded in a separate notebook for later use. This was done to ensure the procedure would not unduly bias the investigator. The remains were locked away for a three month period. At the end of this period, bags were selected randomly by another person, and I then analyzed each of the 24 limbs. My goal was to find evidence of sharp force trauma, and identify the weapon. When an area of sharp force trauma was identified, an electronic sliding caliper was used to record the trauma in millimeters. In cases where burned soft tissue still attached to the limbs, a scalpel was used to remove it for better observation of bone surfaces.

Bag # 7238001 (Fig. I): Defects consistent with sharp force trauma were noticeable on the remains. The first cut measured 16.0 mm in length and 1.33 mm in width, and was oriented across the midshaft of the radius. The second cut measured 21.0 mm long by 1.53 mm wide, and was also oriented across the midshaft of the ulna. The last area of sharp force trauma was 10.0 mm in length and 1.2 mm in width, and was also located on the ulna. On the basis of the length and breadth of the cuts, it was determined that the marks came from either a machete or cleaver. There may have been other areas that contained sharp force trauma, because during the original cutting of the remains more than three cuts were made. However, since the remains were fragmented and the heat from the fire severely damaged the remains, no other areas of sharp force trauma could be identified with confidence.

Fig. I Remains From Bag # 7238001

Bag # 2647800 (Fig. II): Upon opening the bag, three areas of sharp force trauma were noticed immediately. All are circular, or what is often called a puncture-type wound. Each puncture measured approximately 6.9 mm in diameter. Upon further examination, there appeared to be no other indications of sharp force trauma. It was concluded that the sharp force trauma had been caused by an ice pick.

Fig. II Remains From Bag # 2647800

Bag # 1094261 (Fig. III): This bag contained some highly fragmented remains, and only two areas of sharp force trauma could be identified with confidence. First, on the anterior side of the ulna there appears to be a puncture-type wound, similar to that seen on the previous set of remains. The wound measured approximately 7.2 mm in diameter. Second, more evidence of sharp force trauma, 5.8 mm in diameter was found on a carpal bone. Both wounds resemble the sharp force trauma that would be produced from an ice pick.

Fig. III Remains From Bag # 1094261

Bag # 8240013 (Fig IV): One thing that was noticeable about these remains, and that differed from the first three, was the amount of soft tissue still remaining. This was consistent with what was observed during the burning of some of the uncut remains. However, there was one deep "V" shaped cut mark found on the lateral side of the forelimb. This "V" shaped cut was still visible in the soft tissue and terminated at the bone. This cut mark resembled a wound caused by a hacking motion. The cut measured approximately 19.0 mm in length and 1.66 mm in width. No other cut marks were visible on the burned tissue, or on the bone once some of the soft tissue was removed. The sharp force trauma on these remains suggests that it was probably one of the forelimbs subjected to either a cleaver or machete.

Fig. IV Remains From Bag # 8240013

Bag # 0824734 (Fig. V): These remains had virtually no soft tissue left on them, yet they were not highly fragmented. The radius and ulna as well as carpals and metacarpals were mostly intact, making the analysis easier than others. One point of sharp force trauma on the lateral side of the radius was present. This cut measured approximately 11.85 mm in length and 2.58 mm in width. No other areas of sharp force trauma were found on the remains. The cut mark resembled that of a machete or a cleaver.

Fig. V Remains From Bag # 0824734

Bag # 0138647 (Fig. VI): This bag contained remains that were not highly fragmented, but were thoroughly burned. Upon examination of the remains, only one very small cut mark could be identified. The cut was located on the lateral side of the ulna, and ran perpendicular to a fracture caused by the fire. The cut measured approximately 3.70 mm in length and 1.54 mm in width. The cut mark was too small to be caused by a machete or cleaver, and was not circular like an ice pick. The cut resembled a stabbing-type wound that may have been caused by either the serrated or straight edged knife. No other areas of the forelimb were found to have any visible sharp force trauma. The instrument used may not have gone all the way through the tissue to reach the bone.

Fig. VI Remains From Bag # 0138647

Bag # 8809921 (Fig. VII): The seventh bag contained remains that were highly fragmented, and virtually no soft tissue was left. After thoroughly examining the bones, two small cut marks were found on the metacarpals. One measured approximately 5.93 mm in length and 1.2 mm in width, while the other measured approximately 4.2 mm in length and 1.3 mm wide. There was also one small area of sharp force trauma found on the anterior side of the ulna at the midshaft. This cut measured approximately 3.9 mm in length and 1.66 mm in width. The size and shape of the wounds indicate that they were most likely the result of either the straight or serrated edged knives.

Fig. VII Remains From Bag # 8809921

Bag # 9903482 (Fig VIII): Remains in the eighth bag had very little soft tissue remaining, and there were two large areas of sharp force trauma that were immediately identified. They both ran transversely on the radius and ulna. Both were large enough that they extended across both the radius and ulna, as if the instrument used was long enough to cover both bones. The distal most cut measured approximately 24.6 mm in length and 1.5 mm in width over the two bones. The second cut measured approximately 25.28 mm in length and 1.5 mm in width. From the size and appearance of these cuts, they were most likely from a cleaver or machete.

Fig. VIII Remains From Bag # 9903482

Bag # 0100234 (Fig. IX): This bag contained some highly fragmented remains. After analyzing the remains, there were no areas found that would indicate sharp force trauma. This would suggest the remains were one of the uncut forelimbs that was exposed to fire, but not subjected to any tool trauma. However, it should be noted that the anterior midshaft of both the radius and ulna were not recovered. They were so fragmented they could not be identified with confidence. It is possible that the fire destroyed the evidence, and they actually were subjected to sharp force trauma. Although, with no evidence to suggest otherwise the conclusion must be that there was no evidence of sharp force trauma on these remains.

Fig. IX Remains From Bag # 0100234

Bag # 2356701 (fig. X): The remains were severely burned on the outside of the bone, and very little soft tissue was left. However, the inside of the shafts still appeared to be untouched by the fire. The fractures caused by heat or sharp force trauma apparently did not penetrate the cortex of the bone, exposing the inside of the shaft to the fire. After examining the remains, no evidence of sharp force trauma could be identified. While there were several fractures, none appeared to be the result of sharp force trauma. These remains appear to be one of the uncut limbs, which would be consistent with the unburned inner portions of the shaft.

Fig. X Remains From Bag # 2356701

Bag # 5582310: These remains had several fire related fractures. No evidence of sharp force trauma could be identified on the radius or ulna; however, there were cut marks that could be seen on a carpal and metacarpal. The one small cut on the metacarpal measures approximately 5.44 mm in length and only about 1 mm in width. The cut runs perpendicular to the bone. The second cut found on a carpal bone is approximately 5.6 mm in length and 1.0 mm in width. The cuts were most likely from a knife.

Bag # 0538236 (Fig. XI): These remains were very fragmented, to the extent that the radius has been virtually destroyed. The carpals and metacarpals did not show any signs of sharp force injury. There is only one area that suggested sharp force trauma had been applied to this limb. There was circular, or puncture-type wound found on the ulna. This measured approximately 3.3 mm in diameter. The shape and size suggests that it was probably made by an ice pick.

Fig. XI Remains From Bag # 0538236

Bag # 5582310 (Fig. XII): The remains were severely burned, with very little soft tissue still present. There are two very small cuts present that would suggest sharp force trauma. The first is located on a metacarpal, and measures 5.40 mm in length by 1.0 mm in width. The other cut is on a carpal and measures 5.6 mm in length by 1.0 and in width wide. The fragmented radius and ulna both show many heat related fractures. These cuts were probably the result of stabbing with a serrated or straight edged knife. No evidence of sharp force trauma was found on the radius or ulna.

Fig. XII Remains From Bag # 5582310

Bag # 7840032 (Fig. XIII): The remains are extremely fragmented, especially the radius and ulna. It is possible these remains had been subjected to a machete or cleaver, since the weight and force of these two instruments could have caused maximum exposure to the fire and produced major fragmentation. However, since these remains were fragmented to such a high degree, it is not possible to identify or make a conclusion about the presence of sharp force trauma on these fragments. Therefore, no instrument can be assigned to these remains, and by default they must be labeled as uncut or no sharp force trauma present.

Fig. XIII Remains From Bag # 7840032

Bag # 4409904 (Fig. XIV): There are two large cut marks on the anterior side of the ulna that extend transversely across the midshaft. The first measures 13.71 mm in length and 1.42 mm in width. The second, located superior to the first, measures 17.1 mm in length by 3.57 mm in width. After removing the burnt soft tissue that surrounded the cuts, the second cut mark was discovered to extend across the radius as well. The cut on the radius measures 5.72 mm in length by 2.74 mm in width at its widest point. This type of sharp force trauma resembles the result of a hacking type wound, and therefore, these cuts are most likely the result of the cleaver or machete.

Fig. XIV Remains From Bag # 4409904

Bag # 3021326 (Fig. XV): This bag contains charred remains with several cut marks. The first to be identified is a small cut mark on the anterior side of the radius, which measured 6.05 mm in length by 1.27 mm in width. There are three small cut marks on the fifth metacarpal, all perpendicular to the bone. All three of these cuts are 5.0 mm in length and only 1.0 mm in width. The size and shape of these wounds indicate that they are most likely the result of the straight or serrated edged knife.

Fig. XV Remains From Bag # 3021326

Bag # 6778521 (Fig. XVI): On these remains there is one very small cut mark on the lateral side of the ulna, with two radiating fractures extending from it. The cut itself only measures 1.8 mm by 1.8 mm. There is one other small cut found near the distal end of the radius, which measures 6.35 mm length and 2.0 mm in width. There are no other areas that show evidence of sharp force trauma, and these small cuts appear to be the result of stabbing type instrument. Therefore, these remains are most likely due to a serrated or straight edged knife.

Fig. XVI Remains From Bag # 6778521

Bag # 2245833 (Fig. XVII): During examination of these remains, there were two points of sharp force trauma that could be identified. They both appear to be a puncture-type wound. One is between two carpals, on the distal end near the radius and ulna. One cut measures around 4.09 mm in diameter. The other puncture is on a metacarpal, and measures 2.97 mm in diameter. No areas on the radius or ulna display sharp force injury. The shape and size of these cuts indicate that they were the result of an ice pick.

Fig. XVII Remains From Bag # 2246833

Bag # 1804302 (Fig. XVIII): The remains are highly fragmented, greasy, and some soft tissue remained. The amount of tissue was surprising given the degree of fragmentation. The inside of the shafts appeared to be unburned and "fresh." After examining the remains, no evidence of sharp force trauma could be found. The amount of grease and tissue left would be consistent with remains that were uncut. Since they did not have open wounds that allowed the fire to quickly reach the inside of the remains.

Fig. XVIII Remains From Bag # 1804302

Bag # 1032894 (Fig. XIX): The remains are highly fragmented. However, unlike the previous set, these remains are thoroughly burned so that virtually no soft tissue remains. The proximal end of the ulna and the anterior portion of the radius midshaft are broken off, and the rest of the limbs have several heat related fracture lines. These fractures could be masking possible evidence of sharp force trauma, nevertheless none could be found. With no evidence of sharp force injury, these remains were labeled uncut.

Fig. XIX Remains From Bag # 1032894

Bag # 3165211 (Fig. XX): The bag was still wet on the bottom from grease, and the bones did not appear to be burned all the way through. Some soft tissue was still present. After removing the soft tissue, no areas of sharp force trauma could be found. There is one very small fracture that almost appears to be radiating from a heat fracture, however it could not be labeled as sharp force trauma with a high level of confidence. Therefore, these remains were labeled as uncut.

Fig. XX Remains From Bag # 3165211

Bag # 4456032 (Fig. XXI): In this set of remains There is one very small cut mark visible on the anterior midshaft of the ulna that measures 5.2 mm in length by 2.1 mm in width. There is a second cut on one of the metacarpals that measures 5.18 mm in length and 1.2 mm in width. These cut marks are most likely from a kitchen or steak knife. All other fractures or visible trauma to the remains appear to be fire related.

Fig. XXI Remains From Bag # 4456032

Bag # 8663214 (Fig. XXII): These remains show a lot of grease and they did not appear to have been burned all the way through. They are, for the most part, still intact and not very fragmented. After examining them, no sharp force trauma could be positively identified. With no evidence of sharp force trauma on the bone, they were labeled as uncut.

Fig. XXII Remains From Bag # 8663214

Bag # 9210438 (Fig. XXIII): On this forelimb has some grease still present along some intact soft tissue, and is, for the most part, not very fragmented. After analyzing the remains, there are some areas of sharp force trauma that could be positively identified. There are two points of entry that would be described as puncture-type wounds. They are located between the ulna and radius, but did leave evidence on the bone. These two wounds each measure 3.6 mm in diameter. While they are small, they do appear to be the result of a sharp instrument. There is also another puncture-type wound in the soft tissue on the posterior side of a carpal. The trauma does not appear to enter the bone. A measurement of this wound could not be taken without destroying it, as the soft tissue is very fragile. From the shape and size of these points of trauma, all wounds were most likely caused by an ice pick.

Fig. XXIII Remains From Bag # 9210438

CHAPTER IV

RESULTS

The results of the post-fire analysis can now be compared with the pre-fire data (Table I and II). When the two sets of data are compared, it becomes clear that there are some limitations in the identification of sharp force injuries to burned remains. These are:

1. During the analysis I was unable to distinguish between cut marks caused by the serrated knife and those caused by the straight edged knife. Therefore, these two categories should be reduced to simply "knife cuts."

2. Examination could not distinguish between sharp force trauma created by a cleaver and that created by a machete. Therefore, these two categories should be reduced to simply "hacking marks."

3. Approximately 70% of the limbs that had sharp force trauma present could be identified as having some kind of sharp instrument applied to them.

4. The detection of sharp force injury was occasionally obscured by fragmentation caused by extreme burning and/or large hacking instruments.

As discussed in the second chapter, models have been developed to help standardize the description and recording of burned remains (Glassman and Crow 1996, Shipman et al, 1984). The Glassman and Crow model for standardized recording focuses on the degree of bodily injury. This model often uses the condition of the torso and limbs as criteria for placement in a particular category. Because the current experiment is only concerned with the forelimbs, the scale is not applicable to this project. The other scale proposed by Shipman, et al (1984), focuses only on the color of the bone. This scale is not applicable in this experiment, because soft tissue is frequently still attached to the bones. Therefore, a new scale has been developed that pertains strictly to the condition of soft tissue and bones of the forelimb. The requirements for each phase are described in Appendix A and included in Tables I and II.

TABLE I

Arranged by Instrument Used: Observations, Analysis, and Results of Daniel Jackson

Bag#	Trauma Before	Found After	Instrument Used	Analysis After	Accelerant Used	Fragmentation Scale
7238001	yes	yes	cleaver	hacking	diesel	4
8240013	yes	yes	cleaver	hacking	gasoline	1
5582310	yes	yes	cleaver	knife	kerosene	1
1032894	yes	no	cleaver	none	turpentine	4
0824734	yes	yes	machete	hacking	turpentine	2
4409904	yes	yes	machete	hacking	diesel	2
3021326	yes	yes	machete	knife	gasoline	2
4456032	yes	yes	machete	knife	kerosene	2
2647800	yes	yes	serrated	ice pick	turpentine	2
2356701	yes	no	serrated	none	kerosene	2
3165211	yes	no	serrated	none	diesel	1
8663214	yes	no	serrated	none	gasoline	3
8809921	yes	yes	straight	knife	gasoline	1
9903482	yes	yes	straight	hacking	turpentine	2
6778521	yes	yes	straight	knife	kerosene	3
2246833	yes	yes	straight	ice pick	diesel	4
1094261	yes	yes	ice pick	ice pick	diesel	4
0538236	yes	yes	ice pick	ice pick	kerosene	3
7840032	yes	no	ice pick	none	turpentine	4
9210438	yes	yes	ice pick	ice pick	gasoline	1
0138647	none	yes	none	knife	turpentine	3
0100234	none	no	none	none	kerosene	3
1804302	none	no	none	none	diesel	3
7113824	none	not analyzed			gasoline	2

TABLE II

Arranged by Fuel Type: The Observations, Analysis, and Results of Daniel Jackson

Bag#	Trauma Before	Found After	Instrument Used	Analysis After	Accelerant Used	Fragmentation Scale
7238001	yes	yes	cleaver	hacking	diesel	4
4409904	yes	yes	machete	hacking	diesel	2
3165211	yes	no	serrated	none	diesel	1
2246833	yes	yes	straight	ice pick	diesel	4
1094261	yes	yes	ice pick	ice pick	diesel	4
1804302	none	no	none	none	diesel	3
8240013	yes	yes	cleaver	hacking	gasoline	1
3021326	yes	yes	machete	knife	gasoline	2
8663214	yes	no	serrated	none	gasoline	3
8809921	yes	yes	straight	knife	gasoline	1
9210438	yes	yes	ice pick	ice pick	gasoline	1
7113824	none	not analyzed			gasoline	2
5582310	yes	yes	cleaver	knife	kerosene	1
4456032	yes	yes	machete	knife	kerosene	2
2356701	yes	no	serrated	none	kerosene	2
6778521	yes	yes	straight	knife	kerosene	3
0538236	yes	yes	ice pick	ice pick	kerosene	3
0100234	none	no	none	none	kerosene	3
1032894	yes	no	cleaver	none	turpentine	4
0824734	yes	yes	machete	hacking	turpentine	2
2647800	yes	yes	serrated	ice pick	turpentine	2
9903482	yes	yes	straight	hacking	turpentine	2
7840032	yes	no	ice pick	none	turpentine	4
0138647	none	yes	none	knife	turpentine	3

The remains that were incorrectly identified during the analysis phase were reexamined in order to better understand why they were misidentified. It became apparent that certain fuel types obscured evidence more than others, and certain instruments were more easily identifiable than others. The primary reason for misidentification and loss of evidence was the extreme fragmentation created by fire. Clearly, turpentine is the most effective accelerant for destroying evidence of sharp force trauma on bones (Table II). Of the six remains burned with turpentine, only one instrument was correctly identified. Even more critical than having mislabeled five of the six remains, is the uncut limb that was labeled as cut with a knife. While this type of false positive only happened one time, it serves as a word of caution for future analysis. This false positive is discussed further in the next chapter.

It also became apparent from Table I that the serrated knife was the most difficult instrument to identify correctly. In fact, not once were the cut marks caused by the serrated knife correctly identified. Three of the four remains exposed to the serrated knife were labeled as uncut, and the fourth was labeled as being stabbed with an ice pick. This indicates that the serrated knife does not produce bone defects in a manner that survives the fire, or the serrated knife may not have always penetrated to the bone through the soft tissue. If the stabs did penetrate the bone, they may have been just small superficial cuts that were destroyed by fire.

While all the remains with cuts or hacks created by the machete and/or straight edged knife were labeled as having sharp force trauma, the particular instrument was not always correctly identified (Table I). These examples of misidentification appear to be a problem with the ability to distinguish between large hacking instruments which were used with light blows, and knife cuts created with heavy force.

The results from the fragmentation scale show that there is a wide range of destruction to the remains (Table II). No fuel type burned all six remains to the point where they were all placed into the same level on the scale. For example, even though turpentine was found to be the most effective in destroying evidence of sharp injuries, the range of destruction varied on the scale from Level 2 through level 4.

What did become apparent was that particular instruments appeared to have been responsible for similar amounts of destruction to the remains (Table I). All the remains that were hacked with a machete fell into Level 2 on the fragmentation scale. This is likely the reason that sharp force trauma was identified on all remains subjected to the machete. The Level 2 is characterized by very little soft tissue and the radius and ulna are still intact. The remains that were left uncut were also found to be similar in the level of fragmentation. Three of the four uncut remains were classified as Level 3, and the other one was classified as Level 2.

CHAPTER V

ANALYSIS AND RESULTS FROM OUTSIDE OBSERVERS

On February 9th 2004, the burned remains were taken to the University of Texas in Austin to be examined by three independent researchers. These three individuals formed the blind test component of the experiment. They were asked to examine the remains and record their observations. Each researcher examined each bag independently from one another. Before taking the remains out of each brown bag, the seven digit catalogue number was recorded on a piece of paper. Researchers were told that these were the burned distal half of pig forelimbs and that some may have sharp force trauma applied to them before being burned. They were asked locate any evidence of sharp force trauma and describe any evidence that was found. They were also asked, if possible, to write what instrument may have caused the sharp force trauma. If no evidence of cut marks were observed, the researchers were requested to record "none" next to the catalogue number. The researchers ranged widely in their level of experience in forensic anthropology. Two of the researchers, Laura Alport and Angela Porter, are Ph.D. anthropology students at the University of Texas with primary research in Primatology. Based on their lack of knowledge in forensic anthropology, they would be considered novices in their experience with burned remains. The third researcher was Dr. Claude Bramblett, retired Professor of Anthropology at the University of Texas. Dr. Bramblett has extensive osteological knowledge from teaching human osteology. This range of experience in human osteology should provide a good spectrum of comparison. My level of knowledge in human osteology exceeds that of Laura and Angela, but is nowhere near the level of expertise that Dr. Bramblett brought to this experiment. Their observations were recorded for all 24 sets of remains. The results of their findings are presented in Table III and IV.

TABLE III

Identifying the Presence of Sharp Force Trauma: A Comparison of Different Observers' Data

Bag #	Trauma Before	Jackson	Alport	Porter	Bramblett
7238001	yes	yes	no	yes	yes
8240013	yes	yes	yes	yes	yes
5582310	yes	yes	yes	no	yes
1032894	yes	no	no	no	yes
0824734	yes	yes	yes	yes	yes
4409904	yes	yes	yes	yes	yes
3021326	yes	yes	yes	yes	yes
4456032	yes	yes	yes	yes	yes
2647800	yes	yes	no	yes	yes
2356701	yes	no	no	no	maybe
3165211	yes	no	yes	yes	yes
8663214	yes	no	yes	yes	yes
8809921	yes	yes	yes	yes	yes
9903482	yes	yes	yes	yes	yes
6778521	yes	yes	no	no	yes
2246833	yes	yes	no	yes	no
1094261	yes	Yes	no	no	unanalyzed
0538236	yes	Yes	no	yes	no
7840032	yes	No	no	no	no
9210438	yes	Yes	no	no	yes
0138647	none	Yes	no	no	no
0100234	none	No	no	no	no
1804302	none	No	no	no	maybe
7113824	none	unanalyzed	yes	yes	yes

TABLE IV

Analysis by Outside Researchers on Possible Instrument Used

The three outside observers who volunteered to help with the experiment were not told what kinds of instruments were used, so their responses were not comparative. Nevertheless, their responses were instructive.

Bag #	Trauma Before	Instrument Used	Alport	Porter	Bramblett
7238001	yes	cleaver	none	large tool	unknown
8240013	yes	cleaver	large	large tool	unknown
5582310	yes	cleaver	small	none	post fire
1032894	yes	cleaver	none	none	rounded
824734	yes	machete	large	knife	unknown
4409904	yes	machete	machete	large tool	deep cuts
3021326	yes	machete	dull	knife	small cuts
4456032	yes	machete	wide	large tool	rounded
2647800	yes	serrated	none	unknown	unknown
2356701	yes	serrated	none	none	unknown
3165211	yes	serrated	unknown	unknown	unknown
8663214	yes	serrated	small cut	knife	unknown
8809921	yes	straight	small cut	Knife	Sliced
9903482	yes	straight	large	small cut	unknown
6778521	yes	straight	None	None	unknown
2246833	yes	straight	None	knife	none
1094261	yes	ice pick	None	none	N/A
538236	yes	ice pick	None	knife	none
7840032	yes	ice pick	None	none	none
9210438	yes	ice pick	None	none	unknown
138647	none	none	none	none	none
100234	none	none	none	none	none
1804302	none	none	none	none	maybe
7113824	none	none	small	unknown	small

CHAPTER VI

DISCUSSION

Prior research on the ability to identify sharp force trauma on burned bones has been limited to a few studies (de Gruchy and Rogers 2002, Smith and Pope 2003, 2004). The previous experiments routinely used one or two instruments, no uncut controls were used, the observers knew before hand the remains had been cut, and none of the previous experiments used liquid accelerant-only fires. This experiment expanded previous research by using different instruments to produce the sharp force trauma, and several different liquid accelerants in the burning process. Other differences from previous studies included the use of uncut bones being burned as controls, and the incorporation of outside researchers in a blind test format.

The original hypothesis was that sharp force trauma would be identifiable after remains had been burned. Previous studies had reported that even after burning, sharp force trauma could still be found. The results indicate that finding sharp force trauma proved to be more difficult than had been originally imagined. The current study showed that while the presence or absence of sharp force trauma was identifiable most of the time (73.9%), the presence of sharp force trauma was missed six times. The missed trauma was mostly due to extreme fragmentation of remains from their burning. Most often, it was the radius and ulna that were broken into numerous small pieces, making it difficult to find cut marks on these elements. This was highlighted by the fact that almost half (N=11) of the remains were scored a Level 3 or 4 on the Fragmentation Scale (Table I, II).

Knowing that some remains were left uncut in the experiment I was hesitant to call some fractures the result of stabbing. The reasoning was that in real forensic casework one does not know if trauma had or had not occurred, so if no diagnostic fracture patterns are recognized one would always conclude "indeterminate" in these cases. A forensic anthropologist should only be as specific as confidence will allow (Glassman 2004). During my analysis, incorrectly labeling remains as having sharp force trauma when in fact none was present happened only once. This was also the case for each of the outside researchers (Table III). However, whereas the outside researchers' false positive occurred on the same specimen, it differed from the same specimen that I falsely identified. More caution should have been taken and if confidence was not high the trauma should be labeled "indeterminate". The forensic anthropologist should never try to make the data fit his or her expectations of what they expect to find.

There was an error made during the analysis that should be noted here. By mistake bag # 5582310 was accidentally handed to me a second time instead of bag # 7113824. The mistake was not realized until my data was compared to the pre-fire data. That is why in the Tables I and II, the word "unanalyzed" is inserted under my analysis for bag # 7113824. Once it was discovered which set was missing from my analysis, it became pointless to examine the remains since the pre-fire data was known. The set of remains that I examined twice, bag # 5582310, was misidentified on both occasions.

Even more difficult than identifying the presence or absence of sharp force trauma was the actual attempt to distinguish which instrument was used to create the cut marks. Initially, it was hypothesized that the sharp force trauma left by each instrument would easily be distinguishable from each other. Beginning with the very first set of remains that I examined, bag # 7238001, it was apparent that differentiating the bone defects caused by a machete and a cleaver would be too difficult. This was also true with the cut marks created by the serrated knife and the straight edged knife. This problem was addressed in the results chapter, where the terms were reduced to simply "hacking marks" and "knife cuts." The ice pick did produce a unique type of wound, and could be distinguished from defects caused by the other types of instruments used in this experiment (Table I). The trauma created by the ice pick was circular in shape, unlike the "V" shape produced from all of the other instruments. The simplified wound categories should serve as a word of caution to forensic anthropologists. Maintaining the use of a non-specific term "sharp force trauma," and limiting the level of specific instruments used to "probably a knife," or "probably a large blade/hacking instrument" will help to reduce future errors.

The unique approaches to the problem of identifying sharp force trauma on burned remains in this study has furthered our understanding of the complexity in interpreting perimortem trauma related to manner of death prior to fire consumption of a victim. The unique variables used in this study produced increased complexity for interpreting cut mark defects that was expressed in lower rates of accurate recognition. However, these variables made the experiment more closely resemble many of the unknowns that are part of actual forensic case work.

APPENDIX A

A STANDARDIZED SCALE FOR DESCRIBING FRAGMENTARY REMAINS OF THE FORELIMB AFTER BEING BURNED:

The following four phase scale was based on the level of destruction that occurred to the bones and soft tissue.

Level "1": There are still large amounts of soft tissue present, and the bones are still intact. This phase represents the least amount of damage to the remains.

Level "2": This phase is characterized by very little soft tissue left on the remains; however the radius and ulna are still intact in this phase.

Level "3": This phase includes remains that have very little or no visible soft tissue. The bones are fragmented in this phase, and the radius or ulna are broken into at least two pieces.

Level "4": This phase represents the greatest level of destruction to the remains from the fire. No soft tissue is visible, and the bones are highly fragmented. The radius and ulna are often broken into multiple small fragments.

APPENDIX B

Pictures Showing Various Stages of Cutting, Burning, and Analysis of Remains

Fig. XXIV Unburned Limbs

Fig. XXV Cleaver Trauma

Fig. XXVI Limbs on Fire

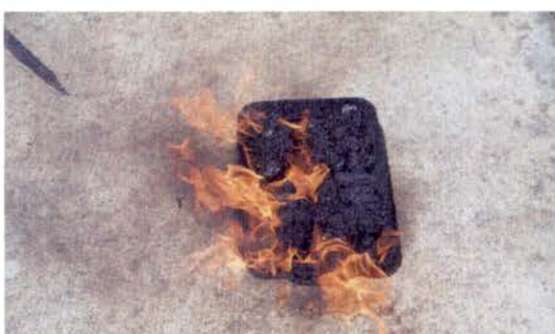

Fig. XXVII Limbs on Fire II

Fig. XXIII Ice Pick Trauma

Fig. XXIX Smoldering Remains

Fig. XXX Stirring Fire

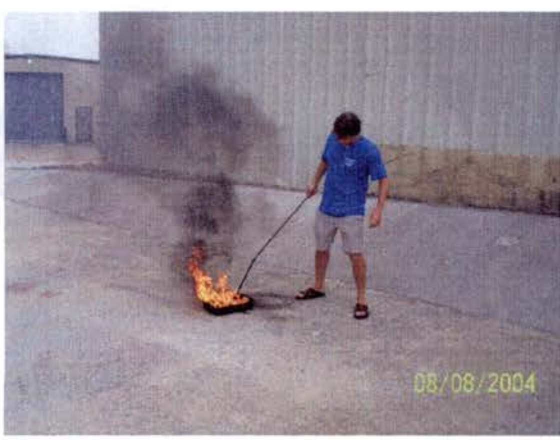

Fig. XXXI Smoldering Remains II

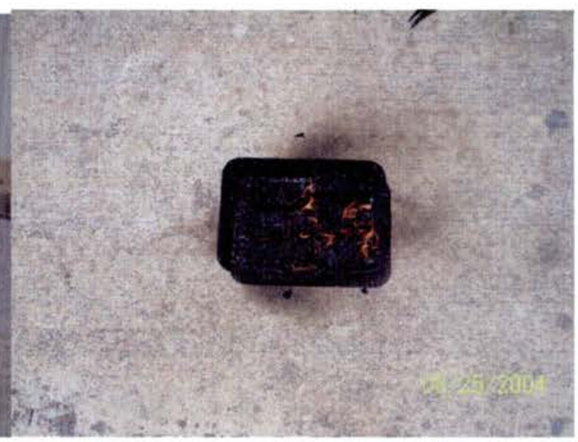

Fig. XXXII Analysis of Remains

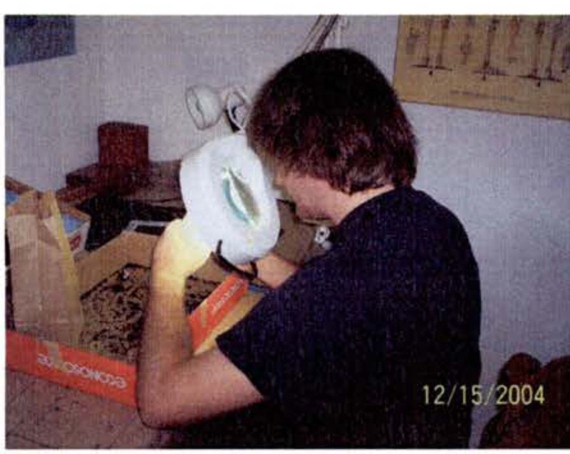

Fig. XXXIII Burned Remains

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