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A matter of questionable death: an analysis of physical child abuse

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A MATTER OF QUESTIONABLE DEATH: AN ANALYSIS OF PHYSICAL CHILD ABUSE

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ABSTRACT

The ability to identify child abuse through skeletal remains is a skill that has generally received little attention. Since the publication of influential articles dealing with battered-child syndrome and shaken baby syndrome, researchers have put more effort toward finding recognizable patterns of physical child abuse. Several studies have found specific fracture patterns associated with child abuse; the humerus, femur and tibia, skull, ulna and radius, and the ribs have all been identified as the most commonly fractured bone resulting from physical child abuse in previous studies. Furthermore, researchers have found that subdural and retinal hemorrhages are the most commonly seen symptoms of shaken baby syndrome.

The present study expands upon the previous studies using a sample of 29 autopsy reports from Shelby County, TN, Jefferson Parish, LA, and Dallas County, TX. Data regarding age at death, sex, type of abuse, presence of soft tissue trauma, presence of shaken baby syndrome symptoms, presence of bone fractures, number and location of bone fractures, and, when available, sex of the perpetrator and relationship of the perpetrator to the victim was collected. Pearson's chi-square tests using SPSS tested correlations between these variables.

The results reveal that the ribs were the most commonly fractured bone. In addition, subdural and retinal hemorrhages occurred in the majority of the shaken baby syndrome victims. Statistical analysis showed that males in this study had a higher chance of suffering fractures because of abuse; specifically, males had a higher chance of having rib fractures. Statistical analyses found no other associations between the victim's sex and fracture location. An association was noted, however, between the victim's age and the occurrence of tibia, femur, ulna, and radius fractures; older victims had a higher occurrence of fractures at these locations. Finally, an association was also found between the victim's age and the type of abuse. Older

victims were more likely to have fractures while younger children were more likely to have only symptoms of shaken baby syndrome.

The results of this study reveal that several patterns of physical child abuse are recognizable within individual studies. On a universal scale, however, it is more difficult to pinpoint specific patterns that occur as a result of physical child abuse. Further studies need to be conducted in order to better understand these patterns.

CHAPTER ONE: INTRODUCTION

While child abuse has always been an issue, the act is a growing phenomenon that is becoming ever more prevalent in today's society. Since 1962, when Kempe first published his classic definition of the battered-child syndrome, anthropologists, psychiatrists, and doctors alike have researched child abuse in much detail. One area that has not received enough attention, however, is identifying child abuse through skeletal remains (Walker 1997).

Child abuse cases are a growing concern for law enforcement agencies worldwide. As Walker (1997) points out, many abusive parents report their child as having been kidnapped, when in reality the parents themselves have murdered their child and hidden the body. In cases such as these, recovery of the body can take weeks, months, or even years. By this point, the body is either partially or fully skeletonized, and physical or forensic anthropologists may be consulted in such cases.

Forensic anthropologists are often assigned the task of examining skeletal remains of child abuse victims, many times without even knowing the nature of the injuries involved. These specialists must search for the clues necessary to point them in the right direction. This thesis analyzes child abuse, specifically the resulting fracture types and patterns, in an effort to provide the necessary information for forensic anthropologists to come to the correct conclusions.

The primary research questions in this project were: (1) How common is skeletal trauma as a result of physical child abuse? (2) Is there a correlation between a child's age and type of abuse? (3) Is there a correlation between a child's age and the location of fractures? (4) Do certain areas of the body fracture more commonly than others in instances of physical child abuse where skeletal trauma is present?

In order to answer these questions, I looked at several studies previously done on child

abuse. Based on the knowledge I learned from these studies, my hypotheses were as follows: (1) Skeletal trauma as a result of child abuse is more commonly seen than soft tissue trauma or trauma resulting from shaken baby syndrome. (2) Young infants have a higher chance of being shaken than do older children. Therefore, symptoms of shaken baby syndrome will more commonly be present in younger children while older children are more likely to suffer strictly skeletal trauma (3) Long bone fractures will more commonly be seen in older children while rib and skull fractures will more commonly be seen in younger children. (4) Ribs fracture most frequently (in large part due to shaking). To test these hypotheses, I analyzed data collected from autopsy reports of children whose deaths were a direct result of physical child abuse. This thesis reports and analyzes the results of that research.

CHAPTER TWO: BONE DEVELOPMENT AND GROWTH

Makeup of Bone

Molecularly, human bone, as well as that of all mammals, regardless of species, is made up of two components: an inorganic matrix and an organic matrix (Shipman et al. 1985). The organic matrix is primarily collagen, which is a protein occurring in long flexible fibers (Shipman et al. 1985). Collagen provides bones with elasticity, flexibility, and strength when placed under pressure. The inorganic matrix is primarily hydroxyapatite, a calcium salt that is deposited in crystals between and within the collagen fibers (Shipman et al. 1985). The organic matrix comprises 24% of adult dense bone while the inorganic portion comprises 76% (Baker et al. 2005). In children, however, the organic collagen portion comprises a larger percentage, which is what accounts for children's bones being more flexible than adults (Baker et al. 2005). These two matrices work together in unison.

Human bone is also composed of two different types of tissue: compact tissue and cancellous tissue. Compact tissue is dense in structure and forms the exterior of the bone (Gray www.bartleby.com/107). Cancellous tissue, on the other hand, is less dense and resembles lattice-work; this forms the interior of bone (Gray www.bartleby.com/107). Periosteum, a rather thick, protective membrane, covers the bone (McLean and Urist 1961). A similar tissue called endosteum lines the marrow cavity of the bone (Shipman et al. 1985).

Bone marrow occupies the cylindrical cavities of long bones as well as spaces between cancellous tissue (Gray www.bartleby.com). In the long bones, the marrow is yellow and consists primarily of fat. In the short and flat bones, however, the marrow is red and consists primarily of water (Gray www.bartleby.com). Red marrow is also found in the articular ends of long bones, the bodies of the vertebrae, cranial diploë, the sternum, and the ribs (Gray

www.bartleby.com).

Bone is "mapped out" in a system of circular districts called Haversian systems. In the center is the Haversian canal, surrounded by rings of bony tissue called lamellae. Situated between the lamellae are the lacunae; canaliculi connect lacunae with neighboring lacunae (Gray www.bartleby.com). Canaliculi and lacunae help in distributing nutrients through every aspect of a Haversian system (Gray www.bartleby.com). Refer to Figure 1 for an example of the Haversian canal system. Though the makeup of bone is complex, everything works together as a system, running smoothly.

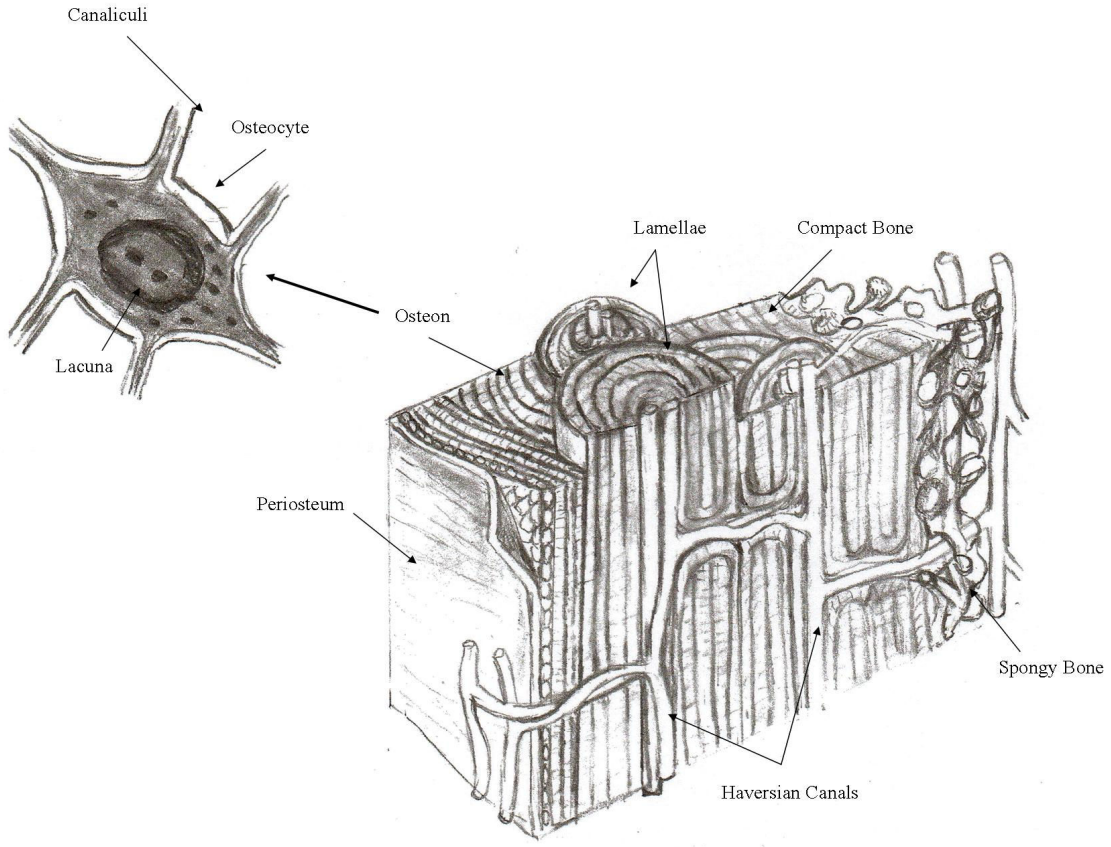

Figure 1: Microstructure of Dense Bone
Illustrated by Bobbye Hamel-Green
Adapted from Tortora 1999. Figure 5.3, p. 111

Bone Development

The development of bone begins in the embryonic stage. Around the fifteenth day after fertilization, a thickening appears around the midline of the ectoderm (Shipman et al. 1985). Cells proliferate and form loose embryonic connective tissue, called mesenchyme, which arranges itself around extracellular spaces (Shipman et al. 1985). A day later, the mesenchyme has formed a new layer, called the mesoderm, which is located between the ectoderm and endoderm (Shipman et al. 1985). Bone formation takes place in one of two ways as the embryo/fetus continues to grow: intramembranous ossification and cartilaginous ossification (also called endochondral ossification).

Intramembranous ossification occurs when the mesenchyme is replaced directly by bone. In the growing embryo/fetus, the parts of the body that undergo this type of ossification are the clavicle, frontal, parietals, nasals, maxillae, vomer, palatines, majority of the mandible, and parts of the sphenoid, temporal, and occipital (Shipman et al. 1985). In the adult skeleton, intramembranous ossification occurs in every part of the body in continuous growth, internal reconstruction, and remodeling of bones (McLean and Urist 1961).

During intramembranous ossification, the ossification center begins as a proliferation of mesenchyme that forms a membrane, which becomes highly vascularized. The mesenchyme serves as osteoprogenitor cells, which are soon transformed into osteoblasts (Shipman et al. 1985). Osteoblasts are bone-forming cells. These cells begin ossifying and remodeling the mesenchyme in the third month after fertilization (Shipman et al. 1985). There exists a delicate balance between bone formation and bone resorption during the modeling and remodeling of bone during intramembranous ossification (Scheuer and Black 2000). As the ossification takes place, a thick tissue remains around the growing bone tissue (Shipman et al. 1985). This tissue becomes the periosteum.

Cartilaginous ossification is the more common method of ossification in the embryonic/fetal stage. Part of the cranium, the limb bones, vertebrae, sternum, ribs, and parts of other bones all undergo this type of ossification as an embryo/fetus (Shipman et al. 1984). In the fourth or fifth week, a cartilage model is formed; this process is called chondrification (Shipman et al. 1985). The mesenchyme cells proliferate and turn into chondroblasts, which are cartilage-forming cells. These chondroblasts later turn into chondrocytes, which produce a cartilage model of bone (Shipman et al. 1985). These changes in cartilage cells occur at certain locations, which become ossification centers for the shafts of bones (McLean and Urist 1961).

The perichondrium, a thick connective tissue, surrounds the cartilage models. This tissue is similar to that surrounding the intramembranous ossification centers (Shipman et al. 1985). In both intramembranous ossification and cartilaginous ossification, these connective tissues contain osteoprogenitor cells that are primarily responsible for creating bone tissue (Shipman et al. 1985). Timing is the key difference between the two. The osteoprogenitor cells are converted into osteoblasts soon after mesenchymal thickening during intramembranous ossification. These osteoblasts then create osteoids, which calcify and become bone (Shipman et al. 1985). The osteoprogenitor cells remain dormant for a long period of time in cartilaginous ossification, allowing the cartilage model to be enlarged by chondrocytes (Shipman et al. 1985).

This cartilage model grows in both length and width. A growth in length is achieved through interstitial growth, which involves the multiplication of chondroblasts at the model's ends; a growth in width is achieved by appositional growth, where the perichondrium contributes new chondroblasts (Shipman et al. 1985). As the cartilage model grows, the matrix between the chondrocytes thins, leaving empty lacunae (Shipman et al. 1985). The chondrocytes in the center of the cartilage model die first, while those around the perimeter remain normal (Shipman et al. 1985). This is due, in part, to the fact that ossification begins at the primary center, which is

within the shaft.

The perichondrium is invaded by capillaries, which transform the perichondrium into periosteum and trigger the osteoprogenitor cells (Shipman et al. 1985). The site where blood vessels enter the cartilage model will become the nutrient foramen (White and Folkens 2005). These osteoprogenitor cells become osteoblasts and begin producing osteoid, or bone, in a thin layer, which quickly calcifies. Almost simultaneously, the central core of the cartilaginous model is also invaded by capillaries carrying osteoblasts and osteoclasts, which are bone resorption cells. In a process called cavitation, these cells break down the cartilage and replace it with bone (Shipman et al. 1985). The calcification proceeds from the center and toward the center at the same time. Osteoclasts resorb calcified cartilage, osteoblasts produce bone, and then the bone is calcified into true bone. This process of bone formation is repetitive and predictable.

Bone Growth

After bone has formed, it must continue to grow in size. Growth in size, while it begins prenatally, continues postnatally. Growth takes place at the epiphyseal growth plate, which is located between the metaphysis and the epiphysis. The metaphysis is the primary center of ossification and the epiphysis is the secondary center of ossification (White and Folkens 2005). Generally, the metaphyses appear before birth, but a few, such as the pisiform of the hand, develop postnatally (Scheuer and Black 2000; White and Folkens 2005). Epiphyses generally appear after birth. Eleven weeks prior to birth, there are approximately 800 ossification centers whereas at birth, there are only 450 (White and Folkens 2005). The epiphyseal plates of long bones are cartilaginous at birth and remain this way for many years (Shipman et al. 1985). According to Scheuer and Black (2000), the term ‘epiphyseal plate’ is inappropriate, as the plate plays no role in the increase in size of the epiphysis; it should instead be referred to as the physis, which is Greek for ‘growth.’

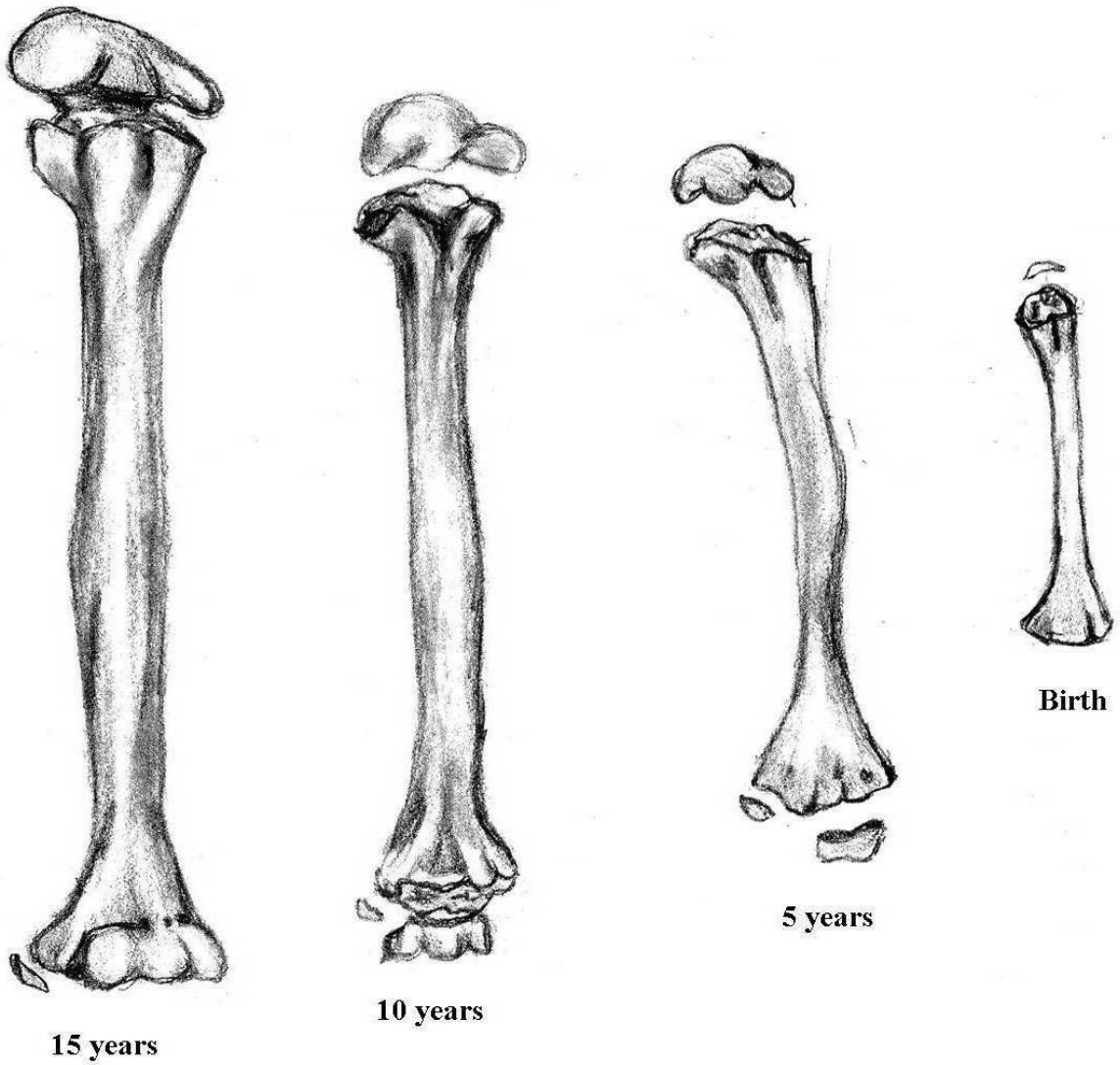

Figure 2: Growth Process of the Humerus
Illustrated by Bobbye Hamel-Green
Adapted from Bass 2005. Figure 3-37, p. 146

The physis is no more than a layer of cartilage and is divided into distinct zones. The germinal zone is the zone furthest away from the diaphysis and closest to the epiphysis. Here, chondrocytes are inactive and randomly distributed (Scheuer and Black 2000). Adjacent to the germinal zone is the proliferative zone, where chondrocytes increase in size as they accumulate glycogen (Scheuer and Black 2000). The zone of cartilage transformation is the area where the chondrocytes begin to hypertrophy and prepare to be replaced by bone (Scheuer and Black 2000). Finally, in the zone of ossification, osteoblasts form a layer of bone around the cartilage. The bone undergoes reorganization through osteoclastic activity and the addition of new bone (Scheuer and Black 2000).

As the bone grows, the plate grows away from the center of the shaft. The cartilage is replaced by bone on the diaphyseal side of the plate. As one grows, the physis is pushed farther away from the metaphysis, which lengthens the bone (White and Folkens 2005). Cartilage proliferation begins to slow as bone maturity approaches; the physis becomes inactive and gradually thins (Scheuer and Black 2000). Once cell division at the physis ceases, ossification and bone growth come to a stop. The epiphysis then fuses with the metaphysis (White and Folkens 2005). This is called epiphyseal fusion and marks the end of longitudinal growth (Scheuer and Black 2000).

Epiphyseal fusion, while generally well documented, is variable. The presence or lack of fusion, however, can prove useful in approximating the age of an individual, as epiphyses generally fuse around given ages. For example, the epiphysis of the distal femur is first present in the third trimester. It remains unfused until ages 15-20, where it generally completely fuses in that five-year time span. The epiphysis of the lesser trochanter of the femur, however, is not present until about the ninth to 12^{th} year of childhood, where it remains unfused until ages 15-20, also completely fusing in that five-year time span (Baker et al. 2005). Of the long bone

epiphyses, only the epiphyses of the medial epicondyle of the humerus and the medial clavicle are not completely fused by ages 20-25 (Baker et al. 2005). Figure 2 is an example of the fusing process bones go through from birth to adulthood.

Remodeling is a process that occurs at the site of the epiphysis once bone growth has halted. Because the ends of the long bones in particular are flared, remodeling must take place to properly fuse the epiphysis with the metaphysis (White and Folkens 2005). Remodeling is also estimated to occur yearly, as a coordinated operation between bone formation and resorption (Scheuer and Black 2000). This remodeling does not necessarily affect the size and shape of the bone, but rather maintains the bone and repairs microscopic damages (Scheuer and Black 2000).

Bone Repair

While bones are the strongest tissue in the body, occasionally, they can break when subjected to abnormal stress or pressure, or when a pathological disease weakens the bone itself. When a bone breaks, the healing process begins immediately. The healing process and new bone formation are very much an automatic process (McLean and Urist 1961).

The healing of a fracture begins with the formation of a hematoma, which is predominantly a bloody mass (White and Folkens 2005). This hematoma coagulates as blood vessels are sealed off. The organization of this hematoma, which is essentially a blood clot, begins within twenty-four hours on all surfaces of the bone (McLean and Urist 1961). The periosteum, which is generally torn at the fracture site, pulls away from the bone; this in turn signals the osteogenic layer of the periosteum to begin forming a callus, which is fracture repair tissue that forms a natural splint (White and Folkens 2005). Initially, the callus consists of fibrous connective tissue connecting the broken bone surfaces; however, within a matter of days, osteoblasts arrive and the callus is mineralized to form woven bone (White and Folkens 2005).

Two types of cells are present at the time of repair: adult bone cells and osteogenic cells

(Ham 1930:829). Ham (1930) found that adult bone cells play no role in the repair of fractures; they "quickly undergo necrosis" and therefore can play no role in proliferation. Following necrosis, these cells leave behind empty lacunae. This is evidence that these cells play no role in the repair process of bone (Ham 1930).

Osteogenic cells, on the other hand, play a large role in bone repair. The osteogenic layer of the periosteum thickens considerably by four days after the injury (Ham 1930). In young individuals, this can occur as early as two days (McLean and Urist 1961). Beginning some distance from the fracture line, the osteogenic cells arise from the periosteum and endosteum and grow toward the fracture line (McLean and Urist 1961). Osteogenic cells located farther away from the actual fracture are lacking an independent blood supply and a local deposit of calcium salts; these cells are found to differentiate into cartilage (Ham 1930). Osteogenic cells nearer the shaft of the bone, however, are in the presence of a good supply of blood and are located adjacent to a deposit of calcium salts; these cells differentiate directly into bone cells (Ham 1930). In time, the cartilage in the fracture is replaced by bone (Ham 1930). The lacunae become enlarged as the matrix calcifies, and osteogenic cells accompanied by blood vessels enter the cartilage, differentiating it directly into bone (Ham 1930). Ultimately, the result of bone repair is the replacement of the cartilage with bone, bony unison of the fracture, and reorganization of the callus (McLean and Urist 1961).

Periosteum plays a key role in bone regeneration. In children, regeneration can be complete, whereas in adults, the result is usually less than perfect (McLean and Urist 1961). In areas of the body where periosteum disappears after growth is complete, such as the patella and the proximal portion of the neck of the femur, endosteal bone becomes the key player in bone repair (McLean and Urist 1961). Where periosteum is plentiful and well developed, regeneration will be rapid and efficient (McLean and Urist 1961).

Juvenile bone repair is for the most part similar to adult bone repair. Both go through the three-step inflammation, reparation, and remodeling process (Lindaman 2001). In children, bone is smaller, more flexible, less brittle, and still growing, which allow for a quicker healing process than in older adults. Less initial stability and callus formation are needed for a child's bone to achieve full strength of the fractured bone. The genes, hormones, and processes that are required for initial bone formation are largely similar, if not identical to those necessary for the healing of fractures. Since juveniles are already undergoing this process of initial skeletal formation, the process of fracture healing is essentially already occurring as well. In an adult, however, these factors must be reawakened, which causes a slower healing time in adults versus children (Lindaman 2001).

Arguably, the most unique property of juvenile bone is its capacity for remodeling over time. A bone's potential to remodel over time depends largely on the number of years of growth remaining (Perona and Light 1990). Since adult bone has significantly fewer years of growth remaining than immature bone, the ability for the bone to remodel in adults is not as great as that found in children. Children also have much stronger, intact periosteum, which plays a vital role in fracture healing. The stronger periosteum contributes to a more rapid formation of callus, or healing bone (Price et al. 2001). Since the periosteum of adults generally weakens over time, the healing process can be slowed.

The development, growth, and repair processes of bone are predictable in both adults and children. In a healthy individual, a time-line of growth and repair can be determined based on these processes. This predictability plays an important role in the detection of fractures. In cases of child abuse, knowledge of bone development, growth, and repair can quickly aid in the detection of abuse.

CHAPTER THREE: WHAT IS CHILD ABUSE?

Definitions of Child Abuse

The term 'child abuse' has several meanings and encompasses several different types of child maltreatment. According to the Child Welfare Information Gateway (2005) - a service of the Children's Bureau - physical abuse, neglect, substance abuse, sexual abuse/exploitation, emotional abuse, and abandonment are all types of child abuse. For this reason, a distinction must be made between these different meanings.

In the United States, some states consider child abuse and neglect as a single concept; both are simply child abuse. Other states provide separate definitions for physical abuse, sexual abuse, neglect, and emotional abuse (CWIG 2005). Sexual abuse is differentiated separately from physical abuse, as is emotional abuse and neglect. This is often an easier system as it minimizes confusion as to what type of child abuse one is discussing.

Under CAPTA (Child Abuse Prevention and Treatment Act), federal legislation has ruled that at a minimum, child abuse and neglect means

- "Any recent act or failure to act on the part of a parent or caretaker, which results in death, serious physical or emotional harm, sexual abuse, or exploitation, or an act or failure to act which presents an imminent risk of serious harm" (CWIG 2005).

By this same Act, child sexual abuse includes:

- "The employment, use, persuasion, inducement, enticement, or coercion of any child to engage in, or assist any other person to engage in, any sexually explicit conduct or simulation of such conduct for the purpose of producing a visual depiction of such conduct; or
- The rape, and in cases of caretaker or interfamilial relationships, statutory rape, molestation, prostitution, or other form of sexual exploitation of children, or incest with children" (CWIG 2005).

By state, the definition of child abuse also differs. Each state must incorporate CAPTA's

minimal definitions of child abuse into the State law. This is important because, theoretically, the definition of child abuse should be universal. For example, the definition of physical abuse in the state of Tennessee states that,

> "*Abuse* exists when a person under the age of 18 years is suffering from, has sustained, or may be in immediate danger of suffering from or sustaining a wound, injury, disability, or physical or mental condition caused by brutality, neglect, or other actions or inactions of a parent, relative, guardian, or caretaker" (CWIG 2005).

Comparatively, the definition of physical abuse in the state of Louisiana states that,

> *"Abuse* means any one of the following acts that seriously endanger the physical, mental, or emotional health of the child:
>
> - The infliction, attempted infliction, or, as a result of inadequate supervision, the allowance of the infliction or attempted infliction of physical or mental injury upon the child by a parent or any other person
> - The exploitation or overwork of a child by a parent or any other person" (CWIG 2005).

Additionally, the definition of physical abuse in the State of Texas states that,

> "*Abuse* includes the following acts or omissions by a person:
>
> - Physical injury that results in substantial harm to the child or the genuine threat of substantial harm from physical injury to the child, including an injury that is at variance with the history or explanation given and excluding an accident or reasonable discipline by a parent, guardian, or conservator that does not expose the child to a substantial risk of harm
> - Failure to make a reasonable effort to prevent an action by another person that results in physical injury or substantial harm to the child
> - The current use by a person of a controlled substance, in a manner or to the extent that the use results in physical, mental, or emotional injury to a child
> - Causing, expressly permitting, or encouraging a child to use a controlled substance" (CWIG 2005).

The definition of child abuse, namely physical child abuse, is of great importance in forensic cases in which a child is undergoing a forensic examination. At times, doctors are quick to jump to conclusions about child abuse. Occasionally, based on their own personal definitions and perceptions of the term, doctors diagnose symptoms as being inflicted as part of abuse. The misdiagnosis of child abuse brings with it many consequences for parents and can be detrimental to a child's health as well (Kaplan 1986). A better understanding of the definition of child abuse, along with a more universal definition, would greatly diminish the possibility of misdiagnosing child abuse.

History of Child Abuse

Historically, child abuse has always been viewed as a deplorable act. Dating back as far as the Middle Ages, child abuse has been viewed as a punishable crime. Pollock (1983) conducted a study in Britain in which she collected child cruelty reports from *The Times* between 1785 and 1860. She found 385 tried cases of child neglect, physical abuse, and sexual abuse. The perpetrators were found innocent in only 27% of these cases (Pollock 1983). This indicates that child abuse and neglect have been condemned as far back as 1785. Pollock (1983:93) writes,

> "The fact that the majority of the cases were also found guilty meant that law and society condemned child abuse long before the specific Prevention of Cruelty to Children Act in 1889. Parents who abused their offspring were generally considered 'unnatural' and the cruelty as 'horrific' or 'barbaric'."

This alone dispels the myth that only in recent times have societies actually taken steps to alleviate the problem of child abuse.

Though the courts were taking action against child cruelty, there were no state intervention laws to directly protect children from abuse from their parents (Corby 2000). Until the end of the 1860s, the state only recognized four categories of children warranting concern. These were children of the street, young offenders, children at work, and children looked after by

the Poor Law authorities (Corby 2000). In the late 1860s and early 1870s, the state became interested in the issue of baby farming – a practice in which parents paid for other people to nurse and care for their infants. Thus began an intervention project in which the state monitored and controlled the practice of baby farming. The Infant Life Protection Society was founded in 1870, and by 1872, they had passed the Infant Life Protection Act. The Infant Life Protection Act required parents fostering more than one child under the age of one to register with local authority and meet certain standards. Later versions of this Act, the 1897 Infant Life Protection Act, the 1908 Children Act, and the 1933 Children and Young Persons Act raised the protected age to nine and made inspections tougher and more comprehensive (Corby 2000).

In the 1880s, different Societies for the Prevention of Cruelty to Children (SPCC) began emerging. The Liverpool SPCC and the London SPCC were first, followed by many other Societies. These joined and formed the National Society for the Prevention of Cruelty to Children (NSPCC) (Corby 2000). In 1889, the Prevention of Cruelty to Children Act was passed. This Act "defined specific parental misdemeanors against children and created penalties for the willful ill-treatment or neglect leading to unnecessary suffering or injury to health" (Corby 2000:25). In 1894, 1904, and 1908, further Acts followed that updated and extended the original Act.

Also at this point in time, child sexual abuse within the family was coming under light. Corby (2000:26) believes that the NSPCC did not bring attention to child sexual abuse in the same way it did other forms of abuse because the general attitude toward the issue at the time was "one of not wanting to know, a conspiracy of silence." Child prostitution, however, received much public attention. In 1885, journalist William Stead, of the *Pall Mall Gazette*, wrote an exposé on a child prostitution ring luring young English girls to a brothel in Belgium. In large part to Stead's work, legislation changed the age of lawful consent to intercourse from 13 to 16

(Corby 2000). Later in 1908, the NSPCC passed the Incest Act, which made incest an officially recognized crime (Corby 2000). This Act set the standard and allowed for more powerful Incest Acts in later years.

Between 1870 and 1914, much improvement in child welfare was seen. Whether the frequency of child abuse actually declined during this period was impossible to determine. Several factors point to the probability of a decrease in child abuse. Immediately following the First World War, however, there was a shift in focus and it is likely that a fair amount of child abuse went unnoticed (Corby 2000).

After the Second World War, there was a dramatic increase in the welfare of deprived children. The Curtis Committee was established in 1946 to "inquire into the conditions of children deprived of a normal home life with their own parents and relatives" (Corby 2000:30). The committee's report detailed several reports of childcare concerns. Importantly, child neglect was only briefly mentioned in the report (Corby 2000). The Curtis Report greatly influenced the 1948 Children Act, which unfortunately paid little attention to child abuse. In 1952, however, the Children and Young Persons Act was amended. The amendment gave children's departments significantly more power to intervene in cases where children were thought to need additional care and protection (Corby 2000). This Act was further amended in 1963, at which point financial assistance was made available to keep children in their own homes, provided this was in the best interest of the child. Amended again in 1969, the Children and Young Persons Act then allowed neglected children to be treated much the same way as children beyond control, children in moral danger, children refusing to go to school, and children committing offences (Corby 2000).

Child abuse was "formally rediscovered" in the United States in 1962 by Henry Kempe (Corby 2000). Kempe and his associate Frederic Silverman coined the term "the battered-child

syndrome" (Kempe and Silverman 1984). Arguably the first to do so, Kempe and Silverman attributed children's injuries to specific acts of maltreatment rather than disease or accidents (Corby 2000). Due in large part to Kempe and Silverman, physical child abuse became an important social issue. Corby (2000:34) writes, "As early as 1967, every state in the USA had mandatory reporting laws and the Children's Bureau was spending considerable amounts of money on research into the problem." Between 1970 and 1985, much of the research on child abuse followed Kempe's model of the battered-child syndrome. The 1975 Children Act focused on the needs of children as being separate from the needs of parents (Corby 2000). The 1989 Children Act provided a greater emphasis on family support and concentrated on alleviating child sexual abuse (Corby 2000). The 1989 Children Act is the most recent federally legislated Act regarding child abuse. Table 1 provides a timeline of the history of child abuse legislation.

Table 1: History of Child Abuse

1800-1870	General concern with children of the streets, children at work, young offenders, and Poor Law children
1861	Offences Against the Person Act
1872	Baby Farming comes into focus Infant Life Protection Act
1877	Societies for the Prevention of Cruelty to Children join to form the National Society for the Prevention of Cruelty to Children
1889	Prevention of Cruelty to Children Act
1908	Children Act Incest Act
1946	Curtis Committee established
1948	1948 Children Act
1962	Henry Kempe and the Battered-Child Syndrome
1975	1975 Children Act
1989	1989 Children Act

Adapted from Corby 2000

The history of child abuse and the myriad acts that were put into place are long and rather complicated. While evidence exists that child abuse was not accepted as far back as the Middle Ages, materialization of the laws currently in place took decades. Though many different acts were involved and resulted in significant advancements, Henry Kempe and Frederic Silverman were vital in creating effective methods to preventing child abuse, especially in the United States.

CHAPTER FOUR: THE BATTERED-CHILD SYNDROME

Henry Kempe and the Battered-Child Syndrome

In 1962, Henry Kempe and Frederic Silverman, in the landmark article titled "The Battered-Child Syndrome," published their well-known definition of the battered-child syndrome. The definition states,

> "The battered-child syndrome, a clinical condition in young children who have received serious physical abuse, is a frequent cause of permanent injury or death….[T]he syndrome should be considered in any child exhibiting evidence of possible trauma or neglect (fracture of any bone, subdural hematoma, multiple soft tissue injuries, poor skin hygiene, or malnutrition) or where there is marked discrepancy between the clinical findings and the historical data as supplied by the parents" (Kempe and Silverman 1984:3294).

They also pointed out that while the battered-child syndrome can occur at any age, it most often affects children younger than three years old (Kempe and Silverman 1984). Along with this definition, they described proper evaluation techniques for physicians. According to Kempe and Silverman (1984:3291), physicians initially should be very suspicious of child abuse "in instances of subdural hematoma, multiple unexplained fractures at different stages of healing, failure to thrive, when soft tissue swellings or skin bruising are present…or in any child who dies suddenly." With this in mind, physicians were further advised to indicate to the parents that they suspected the child was not being properly cared for and to ask the parents to further explain the child's condition (Kempe and Silverman 1984). Kempe and Silverman (1984:3291) also suggest using reasoning statements with the parents, such as "new parents sometimes lose their tempers and are a little too forceful in their actions" in an effort to understand the explanation behind the child's injuries. Kempe and Silverman (1984:3291) warn, "Interrogation should not be angry or hostile but should be sympathetic and quiet." These evaluation techniques were paramount in

advancing the rate of detection of child abuse.

Additionally, Kempe and Silverman discussed the importance that radiographic examination played in the detection of child abuse. They noted that radiographic examination plays two main roles: it is a tool for case finding and acts as a useful guide in management (Kempe and Silverman 1984). Diagnostic signs from radiographs result from four factors: age of the patient, nature of the injury, time elapsed prior to examination, and whether trauma has been repeated or is a single act (Kempe and Silverman 1984). As far as age is concerned, they point out that, generally, for children under three years of age, the amount of radiolucent cartilage is great (1948). It is usually easier to see when the periosteum has been stripped from the shaft of a bone in younger children.

In terms of nature of injury, Kempe and Silverman (1984:3292) write, "The ease and frequency with which a child is seized by his arms or legs make injuries to the appendicular skeleton the most common in this syndrome." Since young children are easily pulled, many traumas occur around their long bones, and Kempe and Silverman felt this was a very important point to stress. As for time elapsed prior to examination, Kempe and Silverman (1984:3292) note, "Unless gross fractures, dislocations, or epiphyseal separations were produced, no signs of bone injury are found during the first week after a specific injury. Reparative changes may first become manifest about 12 to 14 days after the injury." The most important factor in radiographic diagnostics, according to Kempe and Silverman (1984), was whether an injury presents signs of repetition. They warned that repetitive injuries might "produce bone lesions in one area at one time, and in another area at another, producing lesions in several areas and in different stages of healing" (Kempe and Silverman 1984:3292). Physicians were warned to view these indications as classic signs of child abuse.

Kempe and Silverman also went into a brief description of differential diagnoses that are

often presented as alternative explanations to child abuse when looking at radiographic evidence. It was assumed that other diseases were generally "considered only because of the reluctance to accept the implications of the bony lesions" (Kempe and Silverman 1984:3293). Although the radiographic evidence was clear, many physicians apparently were still wary of diagnosing child abuse. According to Kempe and Silverman, scurvy, syphilis, osteogenesis imperfecta, and infantile cortical hyperostosis can present themselves in a similar fashion as child abuse. However, they firmly state, "The radiologic manifestations of trauma are specific, and the metaphyseal lesions in particular occur in no other disease of which we are aware" (Kempe and Silverman 1984:3293).

Kempe and Silverman's work provided unprecedented advancements in the recognition of child abuse and the battered-child syndrome and had significant impact in the medical and anthropological community. They started a battle against child abuse that is being continued to this day.

Recognizing Battered-Child Syndrome

The identification of the battered-child syndrome is the most important and sometimes the most difficult step in identifying child abuse. The importance in being able to detect physical child abuse is two-fold. On one hand, the lives and safety of abused children lie in the ability for doctors, service workers, etc. to recognize abuse. Leventhal (1999:658) writes, "The appropriate recognition of the abused" is "cornerstone" to statewide protective services, treatment facilities, and prevention programs for abused children. Until abuse is recognized and noticed, relief cannot be administered to the child.

At the same time, truly accidental injuries can present themselves as child abuse. Knowing the difference between child abuse and accidental injuries is important because a misdiagnosis of child abuse could lead to children unrightfully being taken from their homes.

Some skeletal fractures can present themselves as other types of trauma rather than child abuse. This makes the job of doctors as well as forensic anthropologists all the more difficult. For example, resuscitation often causes fractures in the rib area. In cases of fatal child abuse, resuscitation has commonly occurred (Betz and Liebhardt 1994). Rib fractures resulting from resuscitation and those resulting from child abuse can closely mimic one another. For reasons such as this, a broad knowledge of the trauma child abuse causes to the body is important.

When detecting child abuse, Cattaneo et al. (2006:132) note, "bone fractures are perhaps the most important and problematic issue as far as detectability is concerned." For this reason, a set of universal and thorough guidelines for assessing suspected child abuse should be established (Cattaneo et al. 2006). Attributing every trauma to child abuse carries grave consequences. As Kaplan (1986:1420) points out, there are "dangers in regarding every unusual injury as abuse." These dangers include the failure to consider other diseases or illnesses causing the symptoms, the patient-physician relationship being irreparably harmed, parents being at risk of unreasonably losing their child, and children unreasonably being placed in foster care (Kaplan 1986). In order to avoid these dangers, physicians as well as physical and forensic anthropologists should be aware of the many maladies that may present abuse-like symptoms.

When forensically examining a victim of child abuse, the ability to assign a timeline to fractures is also imperative. The bones of severely abused children show "multiple antemortem fractures in various stages of healing in anatomically regional patterns" (Kerley 1978:163). These "multiple fractures in various stages of healing [are] the skeletal hallmark of the battered child" (Kerley 1976:337). Recognizing these multiple fractures is crucial, as it indicates that child abuse has likely repeatedly taken place rather than other skeletal maladies.

Dr. James O'Neill and colleagues studied 110 victims of child abuse at Vanderbilt University and Nashville Metropolitan General Hospital in Nashville, Tennessee, over a five-

year period from 1968 to 1972. They analyzed particular patterns of injury, management of injury, and initial diagnosis in an effort to "provide further guidelines for the recognition and care of abused children" (O'Neill et al. 1973:332). Of the 110 children included in the study, 68 were male and 42 were female. Ages ranged from three weeks to 11 years old, and 59 were white and 51 were black (O'Neill et al. 1973).

The patterns found in this study were not surprising. Soft tissue injuries were the most common form of physical abuse. Fifty-five children were admitted primarily for soft tissue injuries; in 49 of these children, the injury was repetitive (O'Neill et al. 1973). Even children admitted for other reasons showed signs of soft tissue injury. Three-fourths of all the children in the study showed signs of either old or new soft tissue injury (O'Neill et al. 1973). When trying to identify child abuse, properly diagnosing soft tissue trauma, when present, is imperative. Unusual injuries such as cigarette burns, excessive scarring, multiple bruises, and lacerations should all heighten the physician's suspicions (O'Neill et al. 1973). O'Neill et al. (1973:337) note, "Soft tissue trauma was usually the earliest manifestation of physical abuse, so recognition of these minor forms of injury in the office or emergency room is one aid to prevention of later more serious forms of abuse which will probably occur." Recognizing soft tissue trauma has the potential to alleviate further physical abuse, and O'Neill and colleagues were quick to point this out.

The second most common problem, as found by O'Neill et al. (1973), was fractures. The fractures, often multiple, usually presented themselves with evidence of previous injury in about half of the cases (O'Neill et al. 1973). Twenty-eight children were admitted primarily for skeletal injury, but there were a total of 35 children who were found to have skeletal fractures. The frequency of fractures was as follows: humerus 20 times, femur 17 times, tibia 10 times, ulna and radius four times each, vertebrae twice and fibula, clavicle, scapula, facial bones and

mandible, one time each (O'Neill et al. 1973). These fracture patterns, O'Neill and colleagues (1973:337) believe, "reflect the types of force to which the child has been subjected." The humerus and femur fractures, being the first and second most commonly fractured bones in this study, "suggest a violent twist of the arm or leg, a sudden jerk on the extremity" (O'Neill et al. 1973:337). This twisting force generally causes spiral fractures, which were commonly seen on the humeri and femurs in this study (O'Neill et al. 1973). Fractures to the rib are third in frequency and display evidence of a child having been crushed or struck with a flat object, which indicates violent child abuse (O'Neill et al. 1973).

Cerebrospinal injury was found to be the third most common type of injury among the 110 children in the study (O'Neill et al. 1973). This type of trauma is common because children are often injured around their faces and heads. O'Neill et al. (1973:338) write, "The head is a favorite target, since it 'represents' the individual." The result is often cerebrospinal injury, which most commonly results in death or retardation. O'Neill et al. (1973) determined that head injury was a late manifestation of child abuse based on the fact that all 32 patients with cerebral trauma had previous soft tissue or skeletal trauma as well.

This study, perhaps the first of its nature, set the stage for further research in the field. O'Neill and his colleagues established a precedent for determining the injury patterns of child abuse; many other studies followed in their footsteps.

Dr. Marvin Kogutt and colleagues performed a study in which two groups of infants were observed and studied. The first group consisted of 100 children seen at The University of Texas Medical Branch between 1967 and 1971. Only 95 of these children had radiographs available for study, so results were based on these children only. In each of these children, battered-child syndrome was diagnosed (Kogutt et al. 1974). The second group of children was made up of infants from group one demonstrating less common types of fractures and additional children

displaying similar unusual skeletal injuries (Kogutt et al. 1974). While the ages of the children in the study ranged from six weeks to eight years, the majority of the children fell between the ages of one and one and a half years. Of the 95 abused children in group one, only 55% had evidence of skeletal fractures. Of these skeletal fractures, the long bones were involved in 34 cases, which equates to 36% (Kogutt et al. 1974).

Importantly, Kogutt and colleagues (1974) point out that in this particular study, the classic multiple fractures and typical epiphyseal-metaphyseal fractures were less common than other fracture patterns and types. Kogutt and colleagues (1974) found that only 22 of the 95 children (23%) had multiple fractures, which, as O'Neill (1973) and Kerley (1976) point out, is a classic sign of battered-child syndrome. Furthermore, only 14 of the 95 patients (15%) had epiphyseal-metaphyseal fractures, which is typical of battered children (Kogutt et al. 1974). Comparatively, 30 of the 95 children (31%) were presented with spiral or transverse fractures of the long bones, most commonly the femur and the tibia (Kogutt et al. 1974). From this, Kogutt and colleagues determined that simply looking for multiple, epiphyseal-metaphyseal fractures could easily lead to battered children not being diagnosed as such (Kogutt et al. 1974). It is equally important, if not more so, to pay special attention to single fractures, as well as spiral and transverse fractures. Kogutt et al. (1974:144) write, "Multiple injuries, especially if seen in various stages of healing, are considered highly suspicious, if not classically diagnostic of the battered child syndrome." Since only 23% of the children in this study showed this pattern of multiple fractures, Kogutt et al. (1974:144) writes, "It may be that one should be more suspicious of solitary fractures when an incongruous clinical history is present."

In group two of this study, many children showed significantly less common and unusual types of fractures. Fractures of the clavicle, sternum, scapula, ribs, and spine were all present in children in group two (Kogutt et al. 1974). While these types of fractures are significantly less

common, each in its own way can give rise to the suspicion of child abuse. Clavicular fractures, from any cause, most commonly occur at midshaft. When a child is presented with a single clavicular fracture at midshaft, it is considered significant only when there are other signs associated with battered-child syndrome (Kogutt et al. 1974). Fractures occurring in the lateral end of the clavicle are far less common, however, and are generally not encountered unless dealing with battered-child syndrome (Kogutt et al. 1974). While most likely the result from a direct blow to the chest, sternal fractures are uncommon and unusual at any time. Unless there is a clear history such as an automobile accident or crush to the chest to accompany a sternal fracture, the possibility of child abuse should strongly be considered (Kogutt et al. 1974).

Likewise, scapular fractures are uncommon. There are two types of scapular fractures: transverse fracture of the scapula, most commonly sustained through direct trauma, and fragmentation of the acromial process, most commonly occurring from severe twisting or shaking (Kogutt et al. 1974). Scapular fractures in general, unless presented with a clear history to substantiate the trauma, should also be viewed with suspicion. Spine and spinal cord injuries are not particularly common in relation to battered-child syndrome, but they have been reported. Spinal trauma generally occurs three ways: anterior notching of the vertebral body, compression of the vertebral body, and fracture-dislocation (Kogutt et al. 1974). Neither of the first two types is common in battered-child syndrome. The third type, however, is characteristic of violent shaking, purposeful and severe direct blows, and whiplash. In cases where fracture-dislocation is apparent, the suspicion of child abuse is greater (Kogutt et al. 1974).

According to Kogutt and colleagues (1974), rib fractures in children are uncommon. This is contradictive to the study done by O'Neill and colleagues (1973), who found that rib fractures were third in frequency in their study of abused children. Kogutt and colleagues (1974) believe that rib fractures are less frequent due to the resiliency of the young thorax. When multiple

fractures are present, especially of the posterior or lateral regions of the rib, the question of abuse should be raised quicker (Kogutt et al. 1974). From this study done by Kogutt and colleagues, it is apparent that multiple, epiphyseal-metaphyseal fractures are not the only indicators of child abuse. Kogutt et al. (1974:149) write, "Certain less common fractures found in our series were felt to be highly suspicious, and might even be considered as valuable a sign of the battered child syndrome as the typical epiphyseal-metaphyseal long bone fracture." Considering each fracture individually and paying close attention to less common types of fractures is important.

Much of the problem with identifying child abuse lies in the fact that physicians and anthropologists alike have had little education in diagnosing child abuse. For physicians, child abuse and family violence are covered only briefly in medical school (Leventhal 1999). Physicians encounter two main problems when the time comes to diagnose child abuse. The first is the tendency for parents to present a false or misleading history to the physician (Leventhal 1999). Physicians expect truthful histories. When parents present untruthful histories, the physician cannot accurately make a diagnosis. Furthermore, even older children tend to learn at an early age the importance of keeping family secrets. Because of this, physicians also get skewed histories from children (Leventhal 1999). All of this easily leads to a misdiagnosis by the physician. Secondly, doctors commonly feel a personal bias related to beliefs, education, attitudes and experience (Leventhal 1999). Since many doctors have little experience dealing with child abuse, they may find difficulty in believing that a parent could inflict harm to a child, especially if the parents present themselves as caring and interact well with the child (Leventhal 1999). In order for physicians to make the correct diagnosis of abuse, they must be aware that child abuse does happen and they need to be suspicious. The education of physicians is equally as important as that of forensic and physical anthropologists in the detection of child abuse.

CHAPTER FIVE: SHAKEN BABY SYNDROME

Defining Shaken Baby Syndrome

A growing concern for society today, shaken baby syndrome is a type of non-accidental physical trauma inflicted upon children. Shaken baby syndrome is only one specific form of child abuse. Shaken baby syndrome can ensue as an isolated form of physical abuse or can occur in conjunction with any other form of abuse (Lancon et al. 1998). According to Monteleone et al. (1994), shaken baby syndrome accounts for more than 50% of infant deaths resulting from physical abuse. Furthermore, shaken baby syndrome is accountable for 10-12% of infant deaths resulting from any type of abuse or neglect (AANS 2000). Clearly, shaken baby syndrome is an important aspect of physical child abuse.

John Caffey made the first reference to shaken baby syndrome in 1946, when he described and categorized a group of six children who presented with chronic subdural hematomas and 23 associated long bone fractures in various stages of healing. Of the long bone fractures, 14 were metaphyseal and nine were diaphyseal (Caffey 1946). A history of trauma was not presented with any of the patients, nor was there evidence of any disease that would likely cause fractures. Caffey concluded that long bone fractures were a common complication of subdural hematoma and that the presence of these fractures should warrant the investigation for subdural hematomas (Caffey 1946).

In 1974, Caffey published another article in which he defined "the whiplash shaken infant syndrome." In this article, Caffey (1974) defined the essential elements of this syndrome as being intracranial and intraocular hemorrhages in the absence of external trauma. Of subdural hemorrhages, Caffey (1974:400) writes, "Subdural hematoma is the most common, most injurious and the least understood lesion in the *shaken* infant, and it is also the most frequently

undetected." He also identified associated traction lesions of long bones with no history of abuse as being an important factor to this syndrome (Caffey 1974). Upon his proposal for a nationwide educational campaign about the whiplash shaken infant syndrome, Caffey (1974:403) advised parents to:

> "Guard well your baby's precious head,
> Shake, jerk and slap it never,
> Lest you bruise his brain and twist his mind,
> Or whiplash him dead, forever."

According to TJ David (1999), other labels, such as "shaken impact syndrome," "whiplash-shaking injury," "inflicted head trauma," "abusive head trauma," and "non-accidental head trauma" commonly refer to shaken baby syndrome. Similarly, according to the American Association of Neurological Surgeons (2000), shaken baby syndrome is also commonly referred to as "whiplash-shaken infant syndrome" or "shaken infant syndrome". The term shaken baby syndrome itself implies an act of violent shaking of a victim by a specific perpetrator (Lancon et. al 1998:13). The perpetrators generally shake the children by the arms, legs, shoulders, or chest, which causes the child's brain to be knocked against the skull wall (AANS 2000). The incident may occur only once, or may be a series of repeated and patterned trauma spanning days, weeks, and months (Lancon 1998). This most commonly results in contusions and edema, cerebral hemorrhage, bleeding within the brain, tears within the brain tissue, blindness, cerebral palsy, seizures, paralysis, mental retardation, permanent brain damage, and even death (AANS 2000).

The symptoms of shaken baby syndrome are often nonspecific and can differ from patient to patient. Table 2 lists a collection of symptoms of shaken baby syndrome from various sources. The classic case of shaken baby syndrome transpires when a child is presented with subdural hemorrhage (blood in the meninges) and retinal hemorrhage (blood in the retina) (Lancon et al. 1998). This is in agreement with Caffey (1974), who also felt that the subdural hemorrhage was the most important indicator. Similarly, Fulton (2000:47) writes, "The hallmark

presentation of SBS is the lack of external trauma in the presence of intracranial and intraocular hemorrhage." There is controversy as to whether subdural hemorrhages or retinal hemorrhages are the most common find in cases of shaken baby syndrome. Duhaime et al. (1998:1827) write, "The most consistent finding in cases of shaken-impact syndrome is the presence of subdural and subarachnoid blood." Lancon et al. (1998:16) write, "With respect to shaken baby syndrome, the hallmark injury is retinal hemorrhage."

Table 2: Symptoms of Shaken Baby Syndrome

• Baby unable to lift or turn head	• Decreased level of /semi-consciousness
• Head turned to one side	• somnolence
• Blood pooling in eyes	• Irritability
• Pupils unresponsive to light	• Poor feeding
• Spasms or seizures	• Vomiting
• Lethargy	• Hypothermia
• Difficulty breathing (including apnea and coma)	• Increased sleeping and difficulty arousing
• Swollen head	• Failure to smile/vocalize
• Dilated pupils	• Bulging fontanel
• Bradycardia	• Complete cardiovascular collapse

Adapted from (AANS 2000), (Duhaime et al. 1998), (Fulton 2000), and (Lancon et al. 1998)

There are three layers of dural coverings of the brain. The outer layer, or dura mater, is tough and lines the inner surface of the skull. The middle layer, the arachnoid mater, is thin and attaches to the overlying dura. The inner layer, or pia mater, adheres intimately to the brain's surface (Lancon et al. 1998). A subdural hemorrhage occurs when there is bleeding between the dura-arachnoid interface of the brain. Clinical presentations of subdural hemorrhages can be acute, subacute, or chronic; this depends on the size of the hemorrhage, amount of time elapsed since initial bleeding, and the hemorrhage's association with other injuries (Lancon et al. 1998).

Subdural hemorrhages are often bilateral and occur in the posterior interhemispheric space or along the cerebral convexities. Large subdural hemorrhages have the ability to displace the brain away from the inner surface of the dura, which can lead to depressed levels of consciousness, coma, and even death (Lancon et al. 1998).

In the shaken baby, retinal hemorrhages most commonly occur in the macula region of the eye. This region is the approximate site of attachment for the vitreous, retinal blood vessels, retina, and optic nerve fibers. Lancon et al. (1998) believe that retinal hemorrhages occur from differential traction between these structures when shaking takes place. Duhaime et al. (1998) assert that retinal hemorrhages occur in about 65-95% of patients while Lancon et al. (1998) claim that retinal hemorrhages exist in 50-100% of patients with shaken baby syndrome. Either way, retinal hemorrhages are generally a clear indicator that abuse has taken place and suspicion should be raised. It is important to take into account that birth often causes retinal hemorrhages. These hemorrhages typically heal quickly, causing no damage to the eye (Lancon et al. 1998).

Due to the many symptoms of shaken baby syndrome, no individual injury is exclusively pathognomonic for shaken baby syndrome. For this reason, the combination of retinal and subdural hemorrhages in children and the absence of a proper explanation for the injuries are highly characteristic of shaken baby syndrome and should raise suspicion (Lancon et al. 1998).

Along with subdural hemorrhages and retinal hemorrhages, skeletal injuries are also common in children presented with shaken baby syndrome. Their presence, however, is not required for the diagnosis of shaken baby syndrome, as only about 50% of physically abused children have skeletal injuries (Lancon et al. 1998). Diaphyseal and metaphyseal fractures of long bones and rib fractures, specifically in the posterior thoracic region, are the most common skeletal injuries with shaken baby syndrome (Lancon et al. 1998).

As Duhaime et al. (1998) have asserted, no medical condition fully mimics all of the

symptoms of shaken baby syndrome. However, since the symptoms of shaken baby syndrome tend to be vague, physicians may initially diagnose a different disease or disorder. Several differential diagnoses exist that potentially may be confused with shaken baby syndrome. Hemophilia and hypoprothrombinemia, which is caused by a vitamin K deficiency, both mimic intracranial hemorrhage in infants (Duhaime et al. 1998). Physical features of osteogenesis imperfecta (also called brittle bone disease), which is an inherited disorder that results in abnormal levels of type I collagen, can often be subtle. This can lead to confusion in whether fractures are a result of child abuse or this specific disease (Duhaime et al. 1998). Glutaric aciduria type I, which is a metabolic disorder due to a glutaryl-coenzyme defect, can easily be confused with shaken baby syndrome as well. With this disorder, infants are presented with developmental delay, hypotonia, and subdural bleeding (Duhaime et al. 1998, Martin et al. 2006). Physicians must be aware of these coagulopathies in order to correctly diagnose shaken baby syndrome.

Victims, Perpetrators, and Risk Factors Associated with Shaken Baby Syndrome

Shaken baby syndrome is classically seen in children under the age of three. The typical victim is under the age of one and more often under the age of six months (Lancon et al. 1998). Injured victims are more frequently males by a ratio of 60% to 40%. (AANS 2000). According to Hennes et al. (2001), premature babies, babies with low birth weights, and babies that received no prenatal care are also at a higher risk for shaken baby syndrome. Several anatomical characteristics of infants cause them to be more susceptible to shaken baby syndrome. An infant's head comprises 10% of its body weight while an adult's head comprises 2% of the total body weight (Fulton 2000). Neck muscles in infants are also weaker compared to those in adults. Because of this, an infant's neck muscles cannot withstand the energy that is produced during shaking. Infants are unable to resist or minimize the forces of injury (Fulton 2000). Relative to

brain injury, an infant's brain has a higher water content, is incompletely myelinated, and has large subarachnoid spaces compared to adults. Together, these anatomies cause differences in movement between an immature and mature brain during shaking (Lancon et al 1998). Clearly, young children are far more susceptible to injuries caused by shaking.

A child's crying is generally the trigger that causes shaken baby syndrome. According to confession statements by perpetrators of child abuse, crying perpetrates shaking more often than any other factor (Giardino 1997). The National Child Abuse and Neglect Data System (NCANDS), a data collection and analysis system headed by the Children's Bureau of the United States Department of Health and Human Services, defines a perpetrator of child abuse as any person who is considered responsible for the maltreatment of a child (USDHHS 2007). Perpetrators typically do not premeditate the shaking. Demographically speaking, most perpetrators of shaken baby syndrome are male. Lancon et al. (1998) found that in military and civilian populations alike, about 90% of perpetrators are male. The victim's biological father is most commonly the perpetrator, with the mother's boyfriend or child-care providers being the second most common perpetrator. A female perpetrator is more likely to be a baby-sitter or child-care provider than the victim's biological mother (Lancon et al. 1998). Similarly, Hennes et al. (2001) found that males (namely fathers) are the most common perpetrator (60-70%), followed by the mother's boyfriend (34%), a baby sitter (4-30%), and a victim's mother (6.5%). Lazoritz et al. (1997) studied 71 victims of shaken baby syndrome; there were 75 suspects in association with these 71 cases. In this study, the victim's father was the most commonly identified perpetrator (33.3%), followed closely by the mother's boyfriend (20%). The mother of the victim was the perpetrator in 6.7% of the cases, while an unrelated sitter was the perpetrator in 4% of the cases. Other relatives (5.3%) and grandparents (4%) were also identified as perpetrators in this particular study (Lazoritz et al. 1997). Clearly, in all of these studies, the

perpetrator is a male over 50% of the time.

Statistics regarding perpetrators of shaken baby syndrome vary slightly to those regarding perpetrators of battered-child syndrome. In a study of child abuse done by the National Child Abuse and Neglect Data System (NCANDS) during Federal fiscal year 2005, researchers found that 79.4% of perpetrators were parents of the victims, 90.5% of which were biological parents. Stepparents accounted for 4.3% of perpetrators while 0.7% were adoptive parents. Unmarried partners of parents made up 3.8% of perpetrators. Other relatives accounted for 6.8% of the perpetrators (USDHHS 2007). Furthermore, 57.8% of perpetrators were female while 42.4% were male (USDHHS 2007). In general, however, NCANDS points out that no single profile of a perpetrator of fatal child abuse exists (USDHHS 2006).

Several risk factors increase the chance of the occurrence of shaken baby syndrome. These risk factors associated with shaken baby syndrome include stress levels of parents, substance abuse, the environment, the child, and childcare. According to Fulton (2000), new parents are often unaware of the basic needs or typical development of infants. This in turn causes the new parents to have unrealistic expectations of their child. At the same time, other parents are still immature and need nurturing themselves, making it difficult to provide nurture to their children. Stress and frustration appear when these expectations go unanswered. Incidences of shaking are directly proportional to the stress and frustration a parent feels (Fulton 2000). Fulton (2000) advises that young parents and single parents, specifically, fall into the risk group because their lack of life experiences and maturity help create added stress and frustration when challenged with an inconsolable infant.

Substance abuse by the parent is also a risk factor that contributes greatly to shaken baby syndrome. Substance abuse causes people to lose inhibition and impulse control, making a person more likely to commit such an act of violence as shaking a baby. Furthermore, infants

who are born to drug-addicted mothers are themselves addicted and will cry inconsolably for extended periods. This places the child at a higher risk of being a victim of shaken baby syndrome, as the mother may perceive the child as always crying (Fulton 2000).

Environmentally speaking, any factor that causes increased stress on the parents can be viewed as a risk factor for shaken baby syndrome. Financial, social, and physical burdens, which contribute to the overall environment, can often be stressful; these stresses put babies at a higher risk. For example, a child is at greater risk if his or her birth created a financial burden on the family (Fulton 2000). The child itself has specific behavioral patterns that can place them at a higher risk for shaken baby syndrome. According to Fulton (2000), infants generally spend approximately 20% of the time crying; infants who have colic cry even more. Inconsolable children often make parents feel helpless and frustrated, thus increasing the risk for shaking.

Another risk factor of shaken baby syndrome is baby sitters. Baby sitters are emerging as likely perpetrators of shaken baby syndrome (Fulton 2000). Generally, baby sitters are adolescents; adolescents are already in the risk category because of their lack of experience and immaturity. Baby sitters often fail to report the onset of symptoms if/when shaking occurs, which makes the time of injury difficult to determine. This leads to a delay in recognition and treatment of symptoms (Fulton 2000).

Many of these risk factors are unavoidable. Some, however, can be lessened with the proper education of parents and baby sitters alike. Parents and caretakers need to be aware of the consequences of shaken baby syndrome and to be educated about its prevention.

Detecting Shaken Baby Syndrome

Since the symptoms of shaken baby syndrome are often non-specific, detection of the syndrome can be difficult. There are several methods, however, that aid in detection. Computerized tomography (CT) is one tool that is effective in evaluating brain injuries. CT is the

preferred method for diagnosing subdural hemorrhage and large axial hemorrhages. CT is also more effective at identifying depressed skull fractures, hairline fractures, and mild compression fractures than conventional radiology (Fulton 2000). Furthermore, with CT, injuries can be roughly dated. Subdural hematoma is the most common symptom of shaken baby syndrome that appears on CT scans (Fulton 2000). According to Duhaime et al. (1998), subarachnoid and subdural bleeding can usually be detected with CT scans. Magnetic resonance imaging (MRI) works well in conjunction with CT. Better sensitivity and clearer evidence of injury is attained through MRI, and it is more useful in aging an injury. Unfortunately, subarachnoid blood and fractures do not show up with MRI. Infants must be sedated in order to undergo MRI, and the overall cost is expensive (Fulton 2000).

While CT and MRI are appropriate for detecting subdural hemorrhages, the most efficient way to detect retinal hemorrhages is with an ophthalmologic examination. Ophthalmologic examinations should be performed on any child when shaken baby is suspected because retinal hemorrhages occur in about 75% of shaken baby victims (Fulton 2000). The presence of a retinal hemorrhage in children under the age of four, except when found during the first month of life, should be an automatic red flag for shaken baby syndrome; for this reason, ophthalmologic examinations should always be included in the detection process of shaken baby syndrome (Fulton 2000).

Depending on which presenting symptoms an infant possesses, a lumbar puncture may be necessary. When vomiting and lethargy are the two main symptoms, a lumbar puncture should be performed to rule out sepsis. During a lumbar puncture, the spinal fluid removed should be clear. Bloody spinal fluid can indicate both subarachnoid and retinal hemorrhages (Fulton 2000).

Radiologic surveys are also an important means of detecting shaken baby syndrome in infants. Skeletal surveys can confirm or rule out other injuries; evidence from older injuries may

be seen with a skeletal survey (Fulton 2000). Duhaime et al. (1998:1824) write, "A skeletal survey is essential in the evaluation of a child for the shaking-impact syndrome, since extracranial abnormalities are detected in 30 to 70 percent of abused children with head injuries." Long bones, skull, ribs, and spine should always be radiologically examined. Special attention should be paid to locating both old and new skeletal injuries. In 25% of shaken baby cases, old and new fractures in the metaphysis and midshaft are present. Ideally, a skeletal survey should be repeated in two weeks because new fractures are often not present until healing begins, which generally takes seven to ten days (Fulton 2000).

In deceased children, an autopsy is imperative for detecting shaken baby syndrome. Overall, pathological findings in children who have been shaken are surprisingly consistent. Evidence of external injury is commonly found during autopsy, and fractures are detected in 25% of infants with shaken baby syndrome (Duhaime et al. 1998). The most consistent autopsy finding of shaken baby syndrome is subdural hemorrhage, which is usually found in the parieto-occipital convexity or posterior interhemispheric fissure (Duhaime et al. 1998). Autopsies often provide the only glimpse a forensic anthropologist has of shaken baby syndrome. This just adds to the importance of performing autopsies on children, especially suspected victims of shaken baby syndrome.

CHAPTER SIX: IDENTIFYING FRACTURE PATTERNS: CURRENT FINDINGS

In 1986, Peter Warlock, Michael Stower and Peter Barbor compared patterns of fractures in accidental injuries to patterns of fractures in child abuse in children living within the Nottinghamshire Health District in England. Two groups were established: a control group (accidental injuries) and a group with non-accidental injuries. The control group was comprised of all children under the age of 12 who were admitted to the accident department of the University Hospital, Nottingham, from January 1 to June 30, 1981; 826 children were initially included in this group (Worlock et al. 1986). The non-accidental injury group consisted of children placed on the Nottinghamshire child abuse register between 1976 and 1982 who lived within the bounds of Nottingham; this group consisted of only 35 children (Worlock et al. 1986). Since no child in the non-accidental injury group was above the age of five, all children in the control group over five were excluded, which resulted in a remaining 116 children under the age of five in the control group for comparison (Worlock et al. 1986). In summary, the accidental injury group consisted of 59 boys and 57 girls and the non-accidental group consisted of 24 boys and 11 girls (Worlock et al. 1986). Worlock and colleagues (1986) determined that there was no significance in the high rate of boys in the non-accidental injury group.

Worlock and his colleagues further broke down the comparisons for this study, examining infants and toddlers separately before looking at all children together. Overall, no child over the age of five was presented with a fracture resulting from abuse; 80% of fractures in abused children occurred when the children were less than 18 months of age (Worlock et al. 1986). Comparatively, 85% of accidental fractures occurred in children over the age of five (Worlock et al. 1986). Fractures of the ribs were determined to be the most common among the abused children, though it is important to note that no child exhibited only rib fractures (Worlock

et al. 1986). The abused infants were the only children to display rib fractures, with 82 fractures identified (Worlock et al. 1986). While there were more skull injuries in the accidental injury group, the fractures were usually single, linear fractures on the parietal bone; in the non-accidental injury group, skull fractures were commonly found to be multiple or complex and usually on the temporal or occipital bone (Worlock et al. 1986). Worlock et al. (1986) posit that larger numbers are needed to establish with certainty that these differences are of any significance.

The usefulness of Worlock et al.'s work is immeasurable by providing guidance to physicians assessing child abuse. They not only broke down their comparisons into toddlers and infants, but they also accounted for specific types of fractures in each group, such as greenstick, spiral, metaphyseal chip, etc. (Worlock et al. 1986). The immense detail in their study paved the way for the recognition of these patterns by physicians and anthropologists alike.

In another study on the fracture patterns found in child abuse, Randall Loder and Christopher Bookout reviewed cases of child abuse from the Children's Hospital in Michigan. They studied 75 cases from 1987-1988, chosen based on the presence of fractures that were deemed definite child abuse by the Child Protection Team at Children's Hospital (Loder and Bookout 1991). Radiographs of each child were reviewed in order to determine which bone was fractured, the fracture pattern (transverse, oblique, spiral, linear) and location (epiphyseal, metaphyseal, diaphyseal), and whether old fractures were present (Loder and Bookout 1991).

In these 75 children, Loder and Bookout (1991) detected 154 fractures. Of these fractures, 118 were new and 36 were old; the most common location for old fractures was the long bones, specifically the tibia (Loder and Bookout 1991). The frequency of fractures was as follows: the long bones had 69 fractures, followed by the skull with 49 fractures and the ribs with 31 fractures (Loder and Bookout 1991). The bones of the skull were the most commonly

fractures; 35 children accounted for the 49 skull fractures (Loder and Bookout 1991). Loder and Bookout (1991) found that the parietal region was the most commonly fractured region of the skull in child abuse (63% were parietal only and 20% were occipital and parietal), which contradicts Worlock et al. (1986), who found in their study that the non-accidental group fractured the occipital and temporal region more, while the accidental injury group fractured the parietal region.

Loder and Bookout (1991) were first to report that the tibia was the most commonly fractured long bone. The radius and ulna, collectively, were the least commonly fractured long bones (Loder and Bookout 1991). Loder and Bookout (1991) compiled findings on the most commonly fractured bones from several studies, as can be seen in Table 3. The table demonstrates the disagreement over which bones are most commonly fractured. This table, as well as this study and the ones preceding it, illustrate that battered children may not always show classic patterns of fracture. The variance in the most commonly fractured bone reported by these different studies may be in and of itself important. While it is important to study these fracture patterns and be aware of them, it is also important to realize that isolated signs of trauma may be indicative of child abuse as well, and not all abuse may fall into a noticeable pattern.

In 1992, Mary Trudell studied emergency room dockets of 118 child abuse patients at Earl K. Long Charity Hospital in Baton Rouge, Louisiana. The sample included children from two weeks to ten years and four months old, and within the sample 75 fractures were noted (Trudell 1992). Trudell (1992) found that the distal forearm (ulna and radius) was the most commonly fractured site. A total of 31 fractures were located on the distal forearm region, constituting 41% of the total fractures (Trudell 1992). The second most commonly fractured sites were the humerus and the femur, both comprising 16% of the total fractures (Trudell 1992). According to Trudell, (1992) fractures of the skull and those of the hand and feet were the least

common. Trudell (1992) classifies skull fractures as being difficult to attribute to child abuse.

Trudell (1992) noted that the majority (71%) of the abuse victims in her study were under the age of two; most children suffering from accidental injury were older than two. This contradicts the findings of Worlock et al. (1986) in which 85% of accidental fractures occurred in children over the age of five.

Table 3: Most Commonly Fractured Bones in Abused Children

Authors	Most Commonly Fractured Bone	Most Commonly Fractured Long Bone
Akbarnia et al. (1974)	Rib	Humerus
Galleno et al. (1982)	Femur	Femur
Herndon (1983)	Skull	Femur
King et al. (1988)	Humerus	Humerus
Children's Hospital of Michigan (1991)	Skull	Tibia

Adapted from Loder, Randall and Christopher Bookout. Fractures Patterns in Battered Children. 1991. Page 432, Table 5.

Other authors discuss fracture patterns in less detail but still provide significant observations. Mininder Kocher and James Kasser (2000) found that there was no "pathognomonic fracture pattern" in child abuse, meaning there was no pattern to fractures; instead, age, overall injury pattern, mechanism of injury, and psychosocial factors must be considered. This contradicts all other studies that claim that fracture patterns are identifiable. Their article serves as an orthopedic guide for understanding the manifestations of physical abuse.

Richard Schwend and colleagues (2000) hypothesized that femur shaft fractures rarely occurred because of child abuse. They claim that whether a child had achieved walking age is the strongest predictor in whether that child's femur shaft fractures are indicative of abuse (Schwend

et al. 2000). Ten of 24 non-walking children were found to have femur shaft fractures because of abuse, while only three of 115 walking toddlers were found to have femur shaft fractures because of abuse (Schwend et al. 2000).

Finally, Behrooz Akbarnia and colleagues (1974) found, from a study of 231 children who were admitted to St. Christopher's Hospital for Children in Philadelphia between 1965 and 1972, that ribs were the most commonly fractured bones. The second most fractured bones were the humeri, followed by the femurs, the skull, hands, ulnae, radii, and miscellaneous bones (Akbarnia et al. 1974). Furthermore, they devised a classification system for metaphyseal, diaphyseal and miscellaneous lesions of bone (Akbarnia et al. 1974).

As is evident from these studies, patterns of abuse in a child's skeleton may appear in various locations. Literature documenting these fracture patterns provides insight as to where fractures resulting from child abuse may occur and provides the backdrop for the current study on fracture patterns seen in cases from coroners and medical examiners.

CHAPTER SEVEN: MATERIALS AND METHODS

In order to complete this thesis, 30 autopsy reports from children suffering from suspected child abuse were examined. I collected 19 from Shelby County, Tennessee, six from Jefferson Parish, Louisiana, and five from Dallas County, Texas. Of the 19 autopsy reports collected from Shelby County, four included types of abuse not commonly thought of in the context of physical child abuse. These included two drowning victims, a gunshot wound victim, and a victim of strangulation. One of these cases was determined to fall outside the child abuse category and was therefore eliminated. The other three were left in the sample because physical abuse was evident. This brought the sample from Shelby Country to 18. My final sample size was 29.

Of these 18 autopsy reports collected from Shelby County, 10 were female and eight were male. Of the autopsy reports collected from Jefferson Parish, two were female and four were male. The sex of the victims was not included in the information I was given from Dallas County. The sample age range was from 17 days to seven years (Figure 3).

Age at death, sex, official cause of death, perpetrator's sex, perpetrator's relationship to victim, and notes about trauma were recorded (as available). Figure 4 represents the general information collection sheet. Specific notes were taken regarding trauma, including whether there was soft tissue trauma and/or skeletal trauma, types of fractures, locations of fractures, and numbers of fractures. Figure 5 illustrates how trauma was recorded on a skeletal trauma collection sheet for each case**.**

After collecting all of the information, I entered the data into Microsoft Excel spreadsheets. The case number, abuse type, sex of victim, sex of perpetrator, relationship of perpetrator, age of victim, age categories of victim, whether or not fractures occurred at six

different fractures sites, and the number of fractures occurring at the six different fracture sites were entered for each victim.

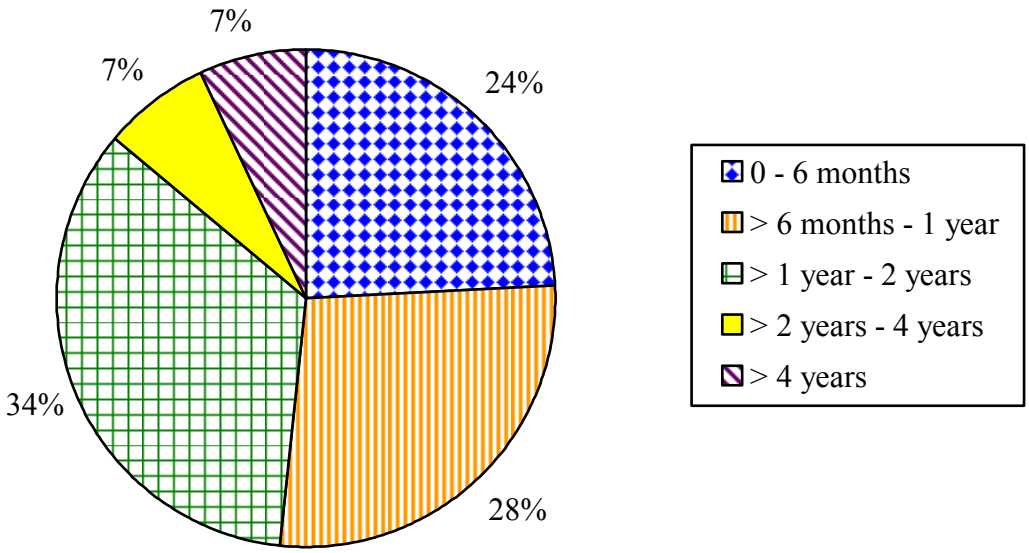

Figure 3: Ages of Victims

Case Number:
Sex:
Age at Death
Cause of Death:
Trauma:
Soft Tissue Trauma:
Sex of Perpetrator:
Relationship of Perpetrator to Victim:
Notes:

Figure 4: General Information Collection Sheet

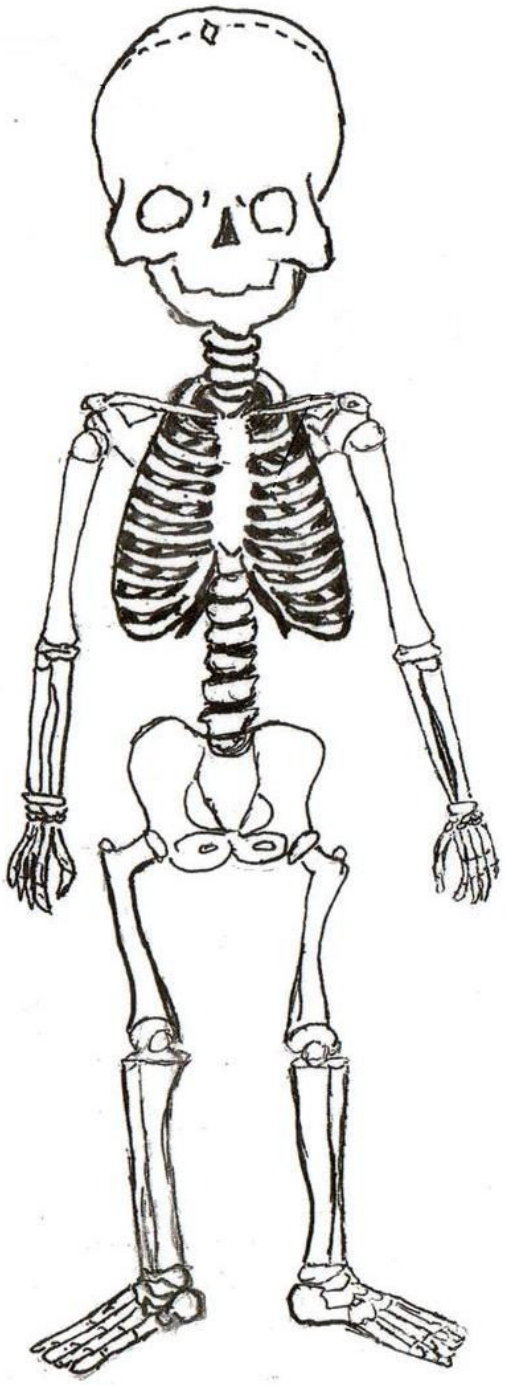

Figure 5: Skeletal Trauma Data Collection Sheet
Illustration by Bobbye Hamel-Green
Adapted from Worlock et al. 1986. Figure 3, p. 101

Subsequently, the data were entered into SPSS version 15 for statistical analysis. Pearson's chi-square analyses were calculated to test the association between age of the victim, sex of the victim, type of physical abuse, site of the fractures, sex of the perpetrator, relationship of the perpetrator, and number of fractures per individual. Statistical significance was evaluated at the level of $P \leq 0.05$.

CHAPTER EIGHT: RESULTS

In the 29 cases in this study, 19 individuals (66%) had fractures of some sort, with a total of 116 fractures. A total of 83 were acute fractures while 33 were healing fractures. The total number of acute versus healing fractures for each individual fracture site is displayed in Table 4. One report did not list a specific number of acute and healing fractures, instead only stating that the victim suffered from "several acute and healing fractures of the ribs". This case is not factored into the total number of fractures. The number of fractures per victim ranged from zero to 21. Several victims did not have any fractures, mainly because they were victims of shaken baby syndrome in which no skeletal trauma occurred, while many had multiple fractures, both healing and acute. This is shown in Table 5. The distribution of the number of total fractures per fracture site is displayed in Figure 6. Table 6 shows the number of individuals per fracture site. Some individuals had fractures in more than one fracture site, so they were counted twice.

Table 4: Total Acute Versus Healing Fractures

Fracture Site	Acute Fractures	Healing Fractures	Total Fractures
Ribs	64	30	94*
Skull	10	2	12
Tibia	3	0	3
Femur	1	0	1
Radius	4	1	5
Ulna	1	0	1
Total*	83	33	116

* These totals do not include the case where a specific number of rib fractures was not given

Table 5: Number of Fractures per Victim

Range of Fractures per Individual	Number of Individuals
0	10*
1	4
2-4	6
5-7	1
8-10	1
11-13	4
14-21	2
Unspecified	1

*8 of these were cases of shaken baby syndrome in which there were no fractures; 2 were other types of abuse that did not result in skeletal trauma

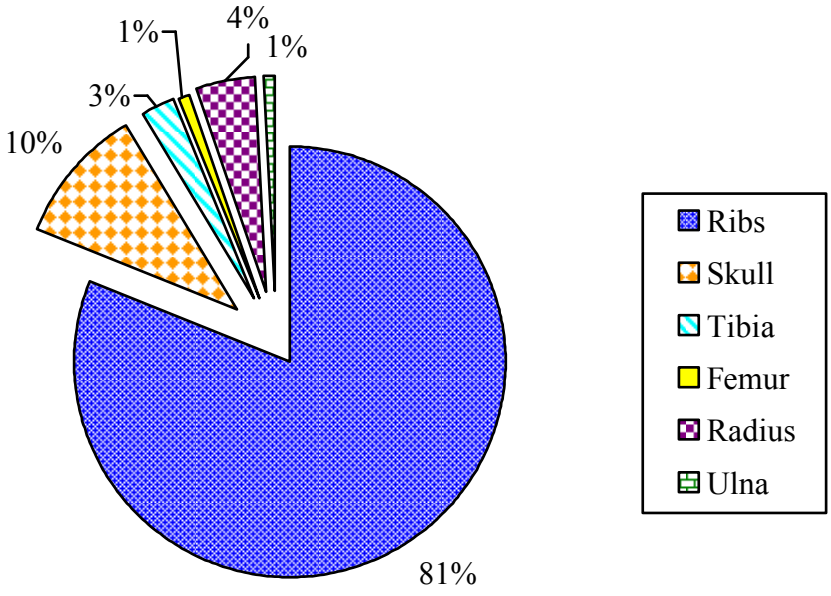

Figure 6: Distribution of Fractures per Fracture Site

Table 6: Number of Individuals per Fracture Site

Fracture Site	Number of Individuals
Ribs	13
Skull	7
Tibia	2
Femur	1
Ulna	1
Radius	4

A total of 16 individuals (55%) in this study had shaken baby syndrome in some capacity. The number of cases that presented with shaken baby syndrome only (eight cases), fractures only (11 cases), and a combination of shaken baby syndrome and fractures (eight cases) was relatively even. This is displayed in Figure 7. Two cases had neither shaken baby syndrome nor skeletal trauma; instead, there was only soft tissue trauma. Soft tissue trauma, whether alone or paired with shaken baby syndrome or skeletal trauma, was present in 22 cases, or 76%. These results do not support my first hypothesis that skeletal trauma is more commonly seen than soft tissue trauma or trauma resulting from shaken baby syndrome.

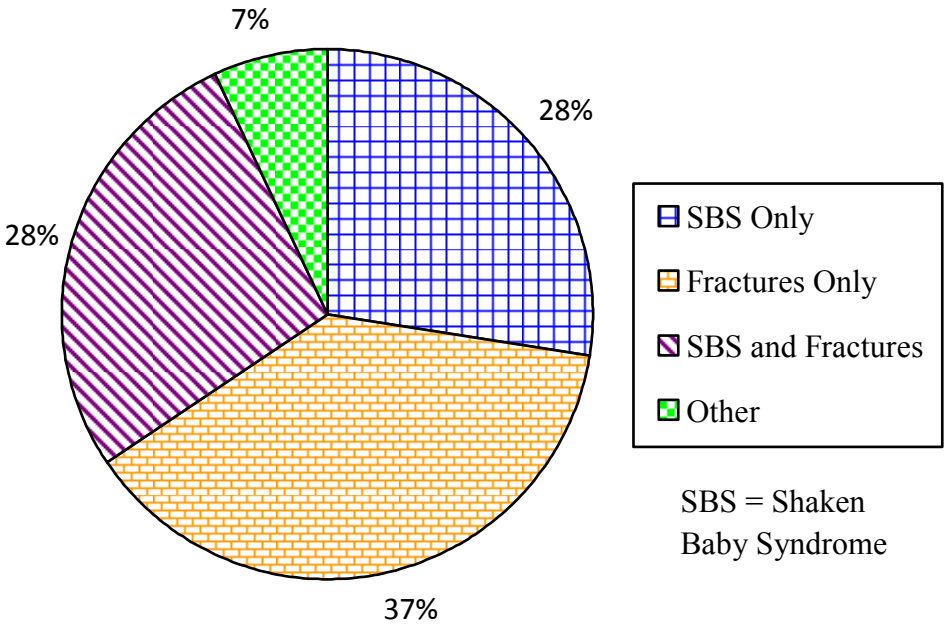

Figure 7: Percentage of Abuse Types

Statistical Analysis

Chi-square (χ^2) tests were run to determine the association between the variables listed in Table 7.

Table 7: List of Variables Used to Determine Associations

1. Perpetrator's sex with:
   - Victim's sex
   - Type of abuse
   - Victim's age

2. Perpetrator's relationship to victim with:
   - Victim's sex
   - Type of abuse
   - Victim's age

3. Victim's sex with occurrence of fractures in:
   - Ribs
   - Skull
   - Tibia
   - Femur
   - Ulna
   - Radius
   - Any location

4. Victim's sex with occurrence of Shaken Baby Syndrome

5. Victim's sex with age

6. Victim's sex with type of abuse

7. Victim's age with occurrence of fractures in:
   - Ribs
   - Skull
   - Tibia
   - Femur
   - Ulna
   - Radius
   - Any location

8. Victim's age with occurrence of Shaken Baby Syndrome

9. Victim's age with type of abuse

To test the statistical significance between the sex of the perpetrator and other variables, as well as the perpetrator's relationship to other variables, chi-square tests were run using only the 24 cases in which the perpetrator's sex and relationship to the victim were known. No statistical significance was found between the sex of the perpetrator and any other variable. There was also no statistical significance between the relationship of the perpetrator to the victim and any other variable. This means that in this particular study, there were no associations between the sex of the perpetrator or the relationship of the perpetrator to the victim to any other variable.

When chi-square tests were run comparing the sex of the victim with other variables, only two showed statistical significance. A statistical significance was determined between the sex of the victim and the occurrence of any fractures; males have a higher chance than females of suffering fractures when abused (Table 8). This test was run using only the 24 cases where the sex of the victim was known. A statistical significance was also found between the sex of the victim and the occurrence of rib fractures (Table 9). This particular test was run using only the 19 cases that had skeletal trauma and the 24 cases where the sex of the victim was known. In this study, more males than females suffered fractured ribs.

Table 8: Relationship between Victim Sex and Presence of Fractures[1]

		Presence of Fractures		Total
		No	Yes	
Victim Sex	Male	2	10	12
	Female	7	5	12
Total		9	15	24

[1] $\chi^2 = 4.44$, df = 1, P = 0.035

Table 9: Relationship between Victim Sex and Rib Fractures[1]

		Presence of Rib Fractures		Total
		No	Yes	
Victim Sex	Male	2	8	10
	Female	4	1	5
Total		6	9	15

[1] $\chi^2 = 5.00$, df = 1, P = 0.025

A statistical significance was found between the victim's age and several other variables. An association was found between the age of the victims and the type of abuse (Table 10). This suggests that there is a correlation between the age of a victim and the type of abuse inflicted upon the children, which supports my second hypothesis. In this particular study, the younger victims were more susceptible to shaken baby syndrome while the older children were more likely to have strictly fractures. The children who fell into the mid-range ages were susceptible to both shaken baby syndrome and fractures.

Table 10: Relationship between Type of Abuse and Victim Age[1]

		Age Categories					Total
		0-6 months	> 6 months – 1 year	> 1 year – 2 years	> 2 years – 4 years	> 4 years +	
Type of Abuse	Shaken Baby Syndrome only	0	4	3	1	0	8
	Fractures only	2	3	5	0	1	11
	Fractures and Shaken Baby Syndrome	5	1	2	1	1	2
	Other	0	0	0	1	1	2
Total		7	8	10	2	2	29

[1] $\chi^2 = 25.1$, df = 12, P = 0.015

In addition, an association was found between the age of victims and the occurrence of fractures in the tibia, femur, ulna, and radius. These four tests were run using only the 19 cases where skeletal trauma was present. Tables 11, 12, 13, and 14 reflect these associations. According to this study, older victims are more likely to suffer tibia, femur, ulna, and radius fractures. This supports the first part of my third hypothesis, that older children will suffer more fractures in the long bones rather than the ribs or skull.

Chi-square tests between the victim's age and rib fractures and victim's age and skull fractures show that there was no statistical significance between these variables ($\chi^2 = 0.983$, df = 3, P = 0.805; and $\chi^2 = 1.20$, df = 3, P = 0.754, respectively). This does not support the second part of my third hypothesis; rib and skull fractures were not correlated with the age of the victim, whereas I postulated that younger children would have a higher instance of these types of fractures.

Table 11: Relationship between Victim Age and Tibia Fractures[1]

		Tibia Fractures		Total
		No	Yes	
Age Categories	0-6 months	6	1	7
	> 6 months – 1 year	4	0	4
	> 1 year – 2 years	7	0	7
	> 2 years – 4 years	0	0	0
	> 4 years +	0	1	1
Total		17	2	19

[1] $\chi^2 = 9.90$, df = 3, p = 0.019

Table 12: Relationship between Victim Age and Femur Fractures[1]

		Femur Fractures		Total
		No	Yes	
Age Categories	0-6 months	7	0	7
	> 6 months – 1 year	4	0	4
	> 1 year – 2 years	7	0	7
	2 years – 4 years	0	0	0
	> 4 years +	0	1	1
Total		18	1	19

[1] $\chi^2 = 19.0$, df = 3, $P < 0.001$

Table 13: Relationship between Victim Age and Ulna Fractures[1]

		Ulna Fractures		Total
		No	Yes	
Age Categories	0-6 months	7	0	7
	> 6 months – 1 yr	4	0	4
	> 1 year – 2 year	7	0	7
	> 2 years – 4 years	0	0	0
	> 4 years +	0	1	1
Total		18	1	19

[1] $\chi^2 = 19.0$, df = 3, $P < 0.001$

Table 14: Relationship between Victim Age and Radius Fractures[1]

		Radius Fractures		Total
		No	Yes	
Age Categories	0-6 months	7	0	7
	> 6 months – 1 year	4	0	4
	> 1 year – 2 years	6	1	7
	> 2 years – 4 years	0	0	0
	> 4 years +	0	1	1
Total		17	2	9

[1] $\chi^2 = 9.90$, df = 3, P = 0.019

CHAPTER NINE: DISCUSSION

Since its publication in 1962, "The Battered-Child Syndrome" by Henry Kempe and Frederic Silverman has been the landmark article with which all researchers have compared their own work on physical child abuse and fracture pattern findings. To this day, it remains an influential reference and guide to detecting and diagnosing the battered-child syndrome. This article has helped not only physicians, but also physical and forensic anthropologists in the recognition of physical abuse manifesting as skeletal trauma. Comparisons of other studies, with each other as well as with Kempe and Silverman's work, are imperative for a better understanding of the patterns and symptoms associated with physical child abuse.

In comparing my results with those of Kempe and Silverman, while there are some similarities, one main difference is evident. In the present study, the ribs were the most commonly fractured bone, which supports my fourth hypothesis. Thirteen individuals (45%) displayed rib fractures, whether alone or in combination with other fractures. These fractures account for 94 (81%) of the total fractures; this total does not include the single individual where the total number of rib fractures was not given. Kempe and Silverman (1984) originally postulated that injuries to the appendicular skeleton were most common in physical child abuse. In the present study, only three individuals (13%) displayed fractures in the appendicular skeleton, accounting for six (8%) of the total fractures. Like Kempe and Silverman (1984) suggested, the majority of abused victims in this study were under the age of three (88%). Furthermore, 22 individuals (76%) had evidence of soft tissue trauma, which as Kempe and Silverman (1984) asserted was highly indicative of physical child abuse.

In comparison to the present study, several other studies found that bones other than the ribs were the most commonly fractured. O'Neill and colleagues (1973) found that the humerus

was the most commonly fractured bone and the ribs were the third in frequency. In the present study, no children exhibited fractures of the humerus. However, O'Neill and colleagues (1973) also found that soft tissue trauma was the most common form of physical abuse, which can also be seen in the present study.

Dr. Marvin Kogutt and colleagues (1974) found that the femur and tibia were the most commonly fractured bone. In the present study, only one individual (3%) displayed femur fractures, accounting for 0.9% of the total fractures; only two individuals (7%) displayed tibia fractures, which accounts for 2% of the total fractures. Kogutt and colleagues (1974) also found that more children in their study displayed single fractures than multiple fractures. In the present study, only four individuals (14%) displayed single fractures, while 15 (52%) displayed multiple fractures. This is not to say, however, that this study suggests that single fractures are any less a sign of physical abuse than multiple fractures.

Like Kogutt and colleagues, Loder and Bookout (1991) found in their study that the tibia was the most common site for healing fractures as well as the most commonly fractured long bone. The most commonly fractured bone in general, however, was the skull. In the present study, seven individuals (28%) displayed skull fractures, accounting for 12 (10%) of the total fractures. The skull was the second most commonly fractured bone in general in the present study, and the tibia was the second most commonly fractured long bone.

In her master's thesis, Mary Trudell's findings were also significantly different from those in the present study. Trudell (1992) found that the ulna and radius were collectively the most commonly fractured bone in her study, which used living children admitted to the emergency room. Additionally, the second most commonly fractured sites were the humerus and femur. Trudell (1992) asserted that skull fractures were the least commonly fractured bones, along with those of the hands and feet. Like Trudell (1992), who found that most of the victims

of child abuse in her study were under the age of two, 86% of victims in the present study were also under age two.

The present study greatly parallels the influential study done by Worlock and colleagues in 1986. Much like the results of the present study, Worlock and colleagues (1986) found that the ribs were the most commonly fractured bone resulting from physical child abuse. As previously mentioned, 13 individuals displayed rib fractures. In only the cases where skeletal trauma was present (19), rib fractures account for 81% of the total fractures. Furthermore, Worlock and colleagues (1986) found that the majority of fractures occurred in children under the age of 18 months. In this particular study, out of the 19 cases where fractures were present, 13 (68%) occurred in children under 18 months of age. Like Worlock, Akbarnia and colleagues (1974) also found that rib fractures were the most commonly fractured bones resulting from child abuse.

Table 15 lists the most commonly fractured bone according to the previous studies as well as the present study. The differences found between the present study and other studies used for comparison in terms of which bone is most commonly fractured because of physical abuse can be accounted for by a couple of factors. First, all other studies previously mentioned dealt with living children while the present study deals only with victims who died as a direct result of child abuse. This study was done on deceased victims of child abuse because of the Health Insurance Portability and Accountability Act of 1996 (HIPAA), which has made it extremely difficult, if not impossible, to do research on living victims of child abuse.

According to the National Center for Child Death Review Policy and Practice, which is a service of the Michigan Public Health Institute and the Maternal and Child Health Bureau of the Department of Health and Human Services, the majority of fatalities due to physical child abuse are the result of abusive head trauma. This head trauma has a high potential for causing fractures of the skull (National Center for Child Death Review Policy and Practice 2005). The second

most common cause of physical abuse deaths in children is from being punched or kicked in the abdomen, which often leads to rib fractures (National Center for Child Death Review Policy and Practice 2005). Given that head trauma and abdomen trauma are the most common factors leading to death due to physical abuse, it makes sense that in the present study the ribs and skull were the most commonly fractured bones rather than the long bones.

Table 15: Comparison of Most Commonly Fractures Bones

Study	Most Commonly Fractured Bone
Kempe and Silverman (1962)	Appendicular skeleton
O'Neill et al. (1973)	Humerus
Kogutt et al. (1974)	Femur and Tibia
Loder and Bookout (1991)	Skull
Trudell (1992)	Ulna and Radius
Worlock (1986)	Ribs
Akbarnia et al. (1974)	Ribs
Present Study (2008)	Ribs

Secondly, the sample size in the present study was relatively small compared with that of the studies used for comparison. This alone is the result of several factors. Several agencies that were contacted in an effort to obtain data either refused my requests for various reasons or were unable to meet my research needs. The biggest problem with collecting data was that most of the medical examiner/coroner offices that I encountered did not have a searchable database. Because of this, obtaining information from agencies other than medical examiners and coroners became mandatory. In relying on law enforcement agencies to collect information, only cases in which an investigation had occurred were available to me. Furthermore, according to the Institutional Review Board (IRB), children are considered a vulnerable population. Because of this, and despite the fact that I had IRB approval, some agencies were unwilling to provide me with

information.

Aside from these two differences, the present study was similar to those used for comparison. All studies looked at only victims of physical child abuse, and all studies used generally the same methods in determining which bone is most commonly fractured because of physical child abuse. Importantly, only two of the comparison studies agreed about which bone was most commonly fractured. Out of the seven comparison studies, there is not "general consensus" of which bone fractured more commonly during physical child abuse. The potential of the present study finding similar results to at least one of the comparison studies was great; comparison studies found six different most commonly fractured bones resulting from physical child abuse. Given this, I postulate that while fracture patterns may be evident within individual studies, it is difficult to say with certainty that any specific bone universally fractures more often because of physical child abuse.

In comparing my statistics on shaken baby syndrome from the present study to other studies, several similarities are evident. Monteleone et al. (1994) found that shaken baby syndrome accounts for more than 50% of infants deaths that result from physical child abuse. Likewise, in the present study, 16 cases (55%) involved shaken baby syndrome, whether alone or with skeletal trauma. Furthermore, Lancon et al. (1998) found that fractures of the long bones and ribs occur more frequently than skull fractures in victims of shaken baby syndrome. In the present study, six victims had either rib or long bone fractures in conjunction with shaken baby syndrome while only two had skull fractures. Lancon et al. (1998) also found that shaken baby syndrome occurs most commonly in children under three. In the present study, all occurrences of shaken baby syndrome occurred in children under the age of three.

In terms of perpetrators, Lancon et al. (1998), Hennes et al. (2000), and Lazoritz et al. (1997) all found that males are the most common perpetrator of shaken baby syndrome.

Specifically, all three studies found that biological fathers are most often the perpetrator. Likewise, in the present study, the biological father was the perpetrator of shaken baby syndrome in 50% of the 12 cases where the perpetrator was known. While these statistics were determined not to be statistically significant, it is still important to point out that the present study does have a higher number of males committing shaken baby syndrome. In order to explore this point fully, a larger sample including only victims on shaken baby syndrome should be studied.

CHAPTER TEN: CONCLUSION

Physical child abuse has been a matter of concern since the Middle Ages. Influential articles such as "The Battered-Child Syndrome" by Henry Kempe and Frederic Silverman (1962) and "Multiple Fractures in the Long Bones of Infants Suffering from Chronic Subdural Hematoma" by John Caffey (1946) have brought the issue of physical child abuse into the limelight within the last century. Since the publication of these articles, subsequent studies have been and are being conducted in order to determine patterns of physical child abuse. In this thesis, I contribute to the information on these patterns of physical child abuse. I collected 29 autopsy reports in which the victim's death was a direct result of physical child abuse from Shelby County, Tennessee, Jefferson Parish, Louisiana, and Dallas County, Texas. While this dataset was smaller than those I used as comparisons, it yielded both expected and unexpected results.

Soft tissue trauma was more commonly present than shaken baby syndrome trauma or skeletal fractures, which was unexpected. A statistical significance was found between the age of a victim and the type of abuse inflicted upon him or her. Older children are more susceptible to having skeletal fractures only, while younger children are more susceptible to sustaining injuries and skeletal trauma resulting from shaken baby syndrome. Older victims are more likely to suffer from fractures of the long bones, which was expected. Rib fractures and skull fractures, however, were no more prevalent in the younger victims than the older victims, which was unexpected. While not statistically significant, the relationship of the perpetrator to the victim displayed similar patterns as those found in comparative studies.

The ribs were found to be the most commonly fractured bone in this study. While this only agrees with two of the comparative studies, there was no consensus between the seven

studies used as comparisons as to which bone was the most commonly fractured. Based on comparing these studies with each other and the present study, I have concluded there is no singular bone that universally fractures more commonly because of physical child abuse. Fracture patterns and most commonly fractured bones, however, can be determined within individual studies. These individual studies, without a doubt, provide immeasurable amounts of information to both physicians and physical/forensic anthropologists alike. These studies provide guidelines and possible patterns that doctors and forensic anthropologists can follow and look for in order to detect physical child abuse easier. With more extensive research, it may be possible in the future to say that a specific bone has a higher possibility of fracturing because of child abuse.

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APPENDIX: AUTOPSY REPORT INFORMATION

Case #	Sex	Age at Death	COD	Notes regarding trauma	Perpetrator Info	Location
1	F	4 years	Drowning	Drowning, murder/suicide, no evidence of abuse	Father	Shelby County
2	F	2 years	Traumatic head injury	Subdural hematoma, subarachnoid hemorrhage, retinal hemorrhage, optic hemorrhage, soft tissue trauma	Father	Shelby County
3	M	3 months	Traumatic head injury	Subdural hematoma, subarachnoid hemorrhage, retinal hemorrhage, 13 fractures – anterior ribs L7,8,9,10, posterior L11, anterior R4,5,6,7,8,9, distal R and L radius, soft tissue trauma	Father	Shelby County
4	M	3 months	Traumatic head injury	Subdural hemorrhage, subarachnoid hemorrhage, optic nerve hemorrhage, retinal hemorrhage, 2 fractures – healing ribs L5 posterior and L6 anterior	Father	Shelby County
5	F	9 months	Shaken baby	Subdural hematoma, retinal hemorrhage and detachment, perioptic nerve hemorrhage, soft tissue trauma	Father	Shelby County
6	M	8 months	Blunt trauma to head	5 fractures – R occipital, healing L parietal, healed R parietal, L6 rib close to death, distal R radius healing, soft tissue trauma	Mother	Shelby County
7	F	2 years	Closed head injury/shaken baby	Subdural hematoma, retinal hemorrhage, soft tissue trauma	Aunt	Shelby County

8	M	17 days	Multiple injuries	Acute rib fractures and healing rib fractures, no specific # specified, soft tissue trauma	Father	Shelby County
9	F	7 years	Strangulation	Strangulation mark, evidence of abuse, soft tissue trauma	Stranger	Shelby County
10	F	11 months	Multiple injuries/shaken baby	Subdural hematoma, subarachnoid hemorrhage (L inferior frontal lobe), retinal hemorrhage, soft tissue trauma	Mother	Shelby County
11	F	2 years	Multiple injuries	9 fractures – acute rib fracture: anterior R6,7,8 and posterior R7,8, healing rob fractures: posterior R9,11 and lateral R11, L radius – greenstick – no signs of healing, soft tissue trauma	Stepfather	Shelby County
12	M	8 months	Head and neck injuries	Whiplash injury, 11 fractures – healing rib fracture proximal R7, non-healing rib fractures distal L7 and R7, near completely healed rib fractures L3,7, R7,8,10,11, medium healing R6, little healing R4, soft tissue trauma	Father	Shelby County
13	F	4 years	Drowning	Posterior scalp contusion, brain swelling, no skeletal trauma, evidence of blunt force trauma, soft tissue trauma	Mother	Shelby County
14	M	14 months	Blunt force injuries	12 rib fractures – sternal: L1,5,9, anterior body: L2,3,4,5,6,7,8, anterior: R6,7, soft tissue trauma	Mother	Shelby County
15	M	5 months	Blunt trauma to head	Left occipital fracture, subdural hematoma, subarachnoid hematoma, retinal hemorrhage, evidence of past trauma	Father	Shelby County

16	M	9 months	Shaken baby	Subdural hematoma	Mother	Shelby County
17	M	2 years	Blunt force injury to head	Acute R occipital skull fracture, subdural hemorrhage, R and L cerebral hemispheres and R and L optic nerves, subarachnoid hemorrhage, retinal hemorrhage	Unknown	Shelby County
18	F	2 years	Gunshot wound to head	2 skull fractures, from entry and exit of bullet, subarachnoid hemorrhage, evidence of blunt force trauma	Unknown	Shelby County
19	F	2 months	Shaken baby	R and L tibia fractures, subdural hematoma	Unknown	Shelby County
20	M	6years	Blunt trauma	12 fractures – Ribs: bilateral R6,8,9,10,11, posterior L9,10,11, L femur, R radius, R ulna, L distal tibia, soft tissue trauma	Unknown	Jefferson Parish
21	F	16 months	Not specified	Skull fracture R posterior cranial fossa to foramen magnum, subarachnoid hemorrhage, soft tissue trauma	Unknown	Jefferson Parish
22	M	7 months	Blunt force trauma	3 fractures – R tempra-parietal occipital (R temporal, R occipital, R parietal), soft tissue trauma	Unknown	Jefferson Parish
23	M	2 ½ years	Assault by mother	Subdural hematoma, subarachnoid hemorrhages, soft tissue trauma	Mother	Jefferson Parish
24	M	174 days	Shaken baby	4 fractures – healing rib fractures: lateral L2,3, posterior L7,8, L subdural hematoma	Unknown	Jefferson Parish
25	F	14 months	Shaken baby	Subdural hematoma	Unknown	Jefferson Parish

26	N/A	1 year	Not Specified	Diastasis of skull sutures, subdural and subarachnoidhematoma, cerebral edema, retinal/optic nerve hemorrhage, soft tissue trauma	Female Babysitter	Dallas County
27	N/A	7 months	Not Specified	Healing Rib fractures: R3,4,5,6,7, L2(x2),3,4,5(x2),6, Healing rib fractures: R6,7, soft tissue trauma	Mother's Boyfriend	Dallas County
28	N/A	3 months	Not Specified	Remote rib fractures: anterior-lateral R3,4,5,6,7,8, L2,3,4,5,6, posterior R9, L6, Acute rib fractures: R3,4,7,9, L4,5,6, linear L parietal fracture, soft tissue trauma	Father	Dallas County
29	N/A	22 months	Not Specified	L6 rib fracture, retinal and optic nerver hematoma, subdural hematoma, soft tissue trauma	Stepfather	Dallas County
30	N/A	2 years	Not Specified	Posterior rib fractures R 10,11, subcutaneous hematoma, bite mark, soft tissue trauma	Mother's Boyfriend	Dallas County

VITA

Carey M. Schwartz was born in Metairie, Louisiana, in December 1982, and soon moved to Collierville, Tennessee. Throughout her life, her family instilled in her the importance of a good education and from there she immersed herself into academia and learning. In 2001, she enrolled at the University of Tennessee, Knoxville, where anthropology soon became her passion. She was graduated from the University of Tennessee, Knoxville, in 2006 with a Bachelor of Arts in anthropology and a Bachelor of Arts in psychology. Wanting to continue her education in anthropology, Carey enrolled at Louisiana State University. While there, she had the opportunity to volunteer for the LSU FACES Lab, directed by Ms. Mary H. Manhein. She plans to graduate in August 2008, from the LSU Department of Geography and Anthropology with a Master of Arts in anthropology. Carey plans to work for a few years before continuing her education and obtaining a doctorate in anthropology. Without a doubt, Carey will continue to embrace anthropology in everything she does.