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Araştırma / Research Article

Forensic Anthropological Approach to Skeletal Traumas in Child Abuse Cases

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Çocuk İstismarı Olgularında İskelet Travmalarına Adli Antropolojik Yaklaşım

Abstract

Objective: Child abuse is an important issue frequently encountered in forensic cases. In this context, skeletal findings are also used in the evaluation of physical evidences. The involvement of forensic anthropologists in the analysis of physical evidence of child abuse also contributes to the work of other experts working in this field. For the examination of the findings of the abuse in the skeleton, forensic osteology knowledge which is one of the main sources of forensic anthropology is needed. This study aims to emphasize the importance of forensic anthropological perspectives in the evaluation of physical findings of child abuse. **Material and Method:** This study analyzes both preliminary and current research and reveals how forensic anthropological approaches can be used to evaluate physical child abuse findings. A compilation study was carried out by evaluating the available sources on the subject. **Results and Conclusion:** Forensic anthropologists specializing in bone development, trauma and fracture types define whether changes in the skeleton and damages are related to abuse. As in most areas, the use of interdisciplinary approaches in cases where child abuse is evaluated increases the reliability of the results obtained. Therefore, different disciplines including forensic anthropology should be used in child abuse researches.

Keywords: Child Abuse, Forensic Anthropology, Human Osteology, Bone Fractures.

Özet

Amaç: Çocuk istismarı, adli vakalar içerisinde sıklıkla karşılaşılan önemli bir konudur. Bu bağlamda fiziksel kanıtların değerlendirilmesinde iskelet bulgularından da yararlanılmaktadır. Çocuk istismarı kökenli fiziksel delillerin analizinde adli antropologların da görev almaları, bu alanda çalışan diğer uzmanların araştırmalarına katkıda bulunmaktadır. İskelete yansıyan istismar bulgularının incelenmesinde adli antropolojinin temel kaynaklarından olan adli osteoloji bilgisine ihtiyaç duyulmaktadır. Bu çalışma, çocuk istismarında fiziksel bulguların değerlendirilmesinde adli antropolojik bakış açılarının önemini vurgulamayı amaçlamaktadır.
Materyal ve Yöntem: Bu çalışma hem öncül hem de güncel araştırmaları analiz ederek çocuk istismarının fiziksel bulgularını değerlendirmek için adli antropolojik yaklaşımlardan nasıl yararlanılabileceğini ortaya koymaktadır. Bu açıdan, konuyla ilgili mevcut kaynaklar değerlendirilerek bir derleme çalışması yapılmıştır.
Bulgular ve Sonuç: Kemik gelişimi, travma ve kırık tipleri konusunda uzmanlaşmış adli antropologlar, iskeletteki değişikliklerin istismardan kaynaklı olup olmadığını tanımlayabilirler. Pek çok alanda olduğu gibi çocuk istismarının değerlendirildiği vakalarda da disiplinlerarası yaklaşımlardan yararlanılması elde edilen sonuçların güvenilirliğini arttırmaktadır. Bu nedenle çocuk istismarı araştırmalarında adli antropoloji de dahil olmak üzere farklı disiplinlere başvurulmalıdır.

Anahtar Kelimeler: Çocuk İstismarı, Adli Antropoloji, İnsan Osteolojisi, Kemik Kırıkları.

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INTRODUCTİON

Clinicians and researchers working in forensic contexts often face cases of child abuse. Many versions of child abuse, including emotional, physical and sexual abuse and neglect cases, have been identified. In this study, the reflection of the traumas caused by physical abuse to the skeleton will be evaluated in terms of forensic anthropology according to current studies.

One of the main aims of forensic anthropology is to provide identification of human skeletons and to obtain clues that can help identify the cause of death by using the findings on the skeleton. In cases of child abuse, various developments that have caused the perpetrators to destroy the bodies or to remove the bodies from the place they were buried long after, necessitates the evaluation of the skeletal remains. If there is insufficient evidence from soft tissues or if confirmatory data are needed in addition to the findings, osteological evidence is used. Forensic osteology is of great importance in this respect.

Forensic anthropologists have specialized in bone trauma and skeletal biomechanics. For this reason, they can present an opinion on the definition of skeletal traumas as an antemortem, postmortem or perimortem in the findings of child abuse reflected in skeleton. The definitions of forensic pathologists and radiologists may be inadequate in the analysis of skeletal remains of abused children. The definition of partial bone remains is also a major disadvantage. Some findings that cannot be determined radiologically in such cases can be defined by anthropologists with osteological knowledge (Walker et al., 1997).

Traumas seen in young children are usually examined in three groups, including birth-related, accidental and abuse-related (Chauvin-Kimoff et al., 2018). Skeletal damage as a result of various accidents, traumas and falls are common in childhood. However, skeletal traumas are also seen in the majority of the abused children. All healthcare providers for children need to have the knowledge of accidental and non-accidental trauma distinctions. They should notify child protection services when necessary (Swoboda and Feldman, 2013). Fatal child abuse and neglect investigations should be conducted with a multidisciplinary approach that requires the coordination of various institutions (Ross and Juarez, 2014).

Distinguishing fractures caused by child abuse from other types of fractures is important in developing clinical guidelines based on obvious evidence. The provision of this information will be an enlightening for case studies as it allows experts who are experts in this field to present their views to the court (Kemp et al., 2008). Identification of the cause of trauma may be disadvantageous because factors such as various skeletal anomalies and metabolic disorders make the bones more fragile than normal.

The reflections of child abuse on the skeleton are analyzed by different procedures in living and dead individuals. In addition, context differences occur in studies such as analysis of archaeological or current remains and according to these contexts, research principles need to be determined.

In this study, it is emphasized that for the evaluation of physical findings of child abuse, forensic anthropology can contribute to case studies. At the same time, it is aimed to indicate the importance of interdisciplinary approaches for forensic sciences in cases of child abuse.

The Role of Child Abuse in Literature

Damage suffered by children was partially ignored since children were often seen as property before the mid-20th century (Ross and Juarez, 2016). Caffey's (1946) research on unexplained subdural hematomas in infants increased the interest in skeletal trauma analysis in subsequent years. researches on child abuse continued radiologically in this context (Bakwin, 1952). As a result of the studies, characteristic radiological findings were defined and child abuse was approached from multiple angles (Kleinman et al., 2015).

Silverman's (1953) description of the radiographic findings of infants with unidentified fractures has been one of the remarkable studies in this area.

Kemp et al. (2008) have made a literature review of fractures occurring as a result of physical abuse and they have compiled the basic indicators of the differentiation of these fractures. They mentioned some possibilities for bone damage based on the cases of abuse.

In the study of Bilo et al. (2010), it was aimed to explain the axial and appendicular skeletal findings as well as the neurological indicators of child abuse. Information was given about the differentiation of accidental and non-

accidental traumas. In this study, radiological findings of bone trauma are also exemplified (Image 1).

Image 1. Fresh rib fractures on the left proximal side with mutual dislocation of the fracture ends (Bilo et al. 2010)

In a basic study emphasizing the importance of forensic anthropologists to take part in child abuse cases, Love et al. (2011) formed an atlas specific to body and skeleton sections. This atlas provides valuable information for forensic anthropologists involved in autopsy practices.

Al-Mahroos et al. (2011a) reported various CT samples in their studies describing the characteristics of abusive head traumas (Image 2) and concluded that these traumas were associated with high morbidity and mortality. They stated that there were no specific symptoms of head trauma due to abuse. The researchers emphasized the need to evaluate the possibility of abuse in the unexplained head traumas and added that multidisciplinary studies are important in this regard.

Image 2. Non-contrast ct scan of the brain of one-year-old male infant, acute-on-chronic right subdural hematoma with marked mass effect and midline shift (Al-Mahroos et al. 2011a)

Ross and Juarez (2016) provided recommendations for evaluating the skeletal and radiological findings of physical abuse and fatal neglect in terms of past societies. According to the researchers, current clinical child abuse protocols will be useful in the evaluation of child abuse in bioarchaeological context.

Holick et al. (2017), in their study on 72 infants under one-year-old have identified non-accidental traumas. Ehlers-Danlos/hypermobility syndrome (EDS) and vitamin D deficiency findings were observed in some infants. Three of the infants with EDS were diagnosed with osteogenesis imperfecta (OI). In the study, it was stated that EDS, OI/EDS and vitamin D deficiency/infantile rickets were related to bone fragility and these fractures could be misinterpreted by confusing with fractures of child abuse.

As a result of the preliminary studies conducted on the basis of child abuse, clinical and radiological indicators were evaluated together and "battered child syndrome" has entered literature (Buchanan, 1985). Skeletal findings that may be indicative of fatal starvation have been analyzed and metabolic diseases have been proposed as evidence of potential neglect (Ross and Juarez, 2016).

Methodology of Trauma Analyzes

Certain applications defined as ''skeletal survey'' are followed in trauma analyzes (Table 1). Skeletal survey (SS) forms the basis of radiographic applications in the analysis of unexplained fractures and is important for identification of occult skeletal injury (Chauvin-Kimoff et al., 2018). Skeletal examinations are widely used radiologically in primary suspicions of physical abuse of infants and young children (Day et al., 2006).

Table 1. Procedure of skeletal survey (Brogdon et al. 2012)

Frontal and lateral skull
AP supine and lateral chest (including visualization of the lateral thoracic spine)
AP lumbar spine and pelvis
Lateral lumbar spine
AP upper extremities a (with forearms in supination)
PA hands
AP lower extremities a (with toes slightly inverted)
AP feet

In addition to X-ray evaluation, bone scintigraphy is also used for suspicion of child abuse. The biggest advantage of this technique is that it is sensitive to 25% to 50% in the detection of soft tissue and bone traumas (Conway et al.,

1993). Bone scintigraphy is important for the identification and characterization of traumas caused by child abuse. Interpretation of scintigraphic images depends on the understanding of radionuclide regions in the bone. Radionuclide scintigraphy is a complementary practice rather than a primary method for diagnosing physical child abuse (Conway et al., 1993).

The theoretical basis for examining and interpreting skeletal damage is based on four main topics (Love and Soto Martinez, 2017):

- Skeletal growth and development (foundational theory)
- Bone biomechanics (interpretive theory)
- Childhood motor skill development (interpretive theory)
- Injury prevalence (methodological theory)

The evaluation of all these forms of theory requires the identification of accidental and non-accidental skeletal damages and the collection of as much evidence as possible about the separation of these damages (Love and Soto Martinez, 2017). Neuroimaging is also recommended for infants with suspected fractures and maltreatment (Chauvin-Kimoff et al., 2018).

Relationship Between Skeletal Traumas and Age

It is stated by different researchers that it is necessary to pay attention to certain age ranges in order to evaluate the physical findings of child abuse. In this respect, it is essential to define age groups and age ranges (Table 2). The findings of age and developmental status are important in the evaluation of suspicions of child abuse through skeletal trauma. Special attention is required in cases of developmental disorders (Swoboda and Feldman, 2013). Therefore, researchers who carry out such studies should have knowledge about bone development. For example, knowing epiphyseal fusion ages in epiphysis fractures will be effective in the separation of fractures for abuse. Detection of trauma time is also important in the analysis of fractures at different ages (Chauvin-Kimoff et al., 2018). This information provides reliable evidence for physical abuse.

Table 2. Age groups and age ranges (Militaru and Martinovici 2005)

Newborn	0 day to 1 month
Infant	1 month to 1 year
Toddler	1 to 3 years
Pre-school	3 to 6 years
School age child	6 to 12 years
Adolescent	12 to 18 years

Childhood stage is the most dynamic period of bone growth and mineralization. The evaluation of fracture area, fracture type and development stage of the child helps the detection of the fractures of abuse originated (Kemp et al., 2008; Chauvin-Kimoff et al., 2018). Skeletal traumas caused by physical abuse are seen in infant and toddler age which can not make causal explanation and these traumas are mostly hidden (Day et al., 2006). Children under 18 months are less likely to have accidental fractures (Worlock et al., 1986). The incidence of accidental fractures increases with age and developmental abilities (Swoboda et al., 2013).

Fractures are seen 11% to 30% in infants and children with suspected physical abuse (Belfer et al. 2001). In such cases, fractures resulting from abuse or maltreatment are defined as ‘‘inflicted’’ (Chauvin-Kimoff et al., 2018). Consideration should be given to the possibility of physical abuse of bone fractures in a baby or toddler when there is no history of metabolic bone disease or significant bone trauma (Al-Mahroos et al., 2011b).

Multiple fractures are closely associated with abuse cases in many cases (Worlock et al., 1986; Kemp et al., 2008). There may be signs of physical abuse on various bones. For example, fractures in the processus spinosus of scapula and sternum are not common. These fractures are suspicious for child abuse.

In some studies, fracture forms in different age groups have been associated with physical abuse. For example, metaphysis and rib fractures below one-year-old were defined as high risk indicators for child abuse. Fractures of the humerus seen below 18 months and femur fractures in children who have not been able to walk increase the likelihood of abuse (Chauvin-Kimoff et al., 2018). Humerus and femur fractures may also occur due to nursery mistakes (Image 3).

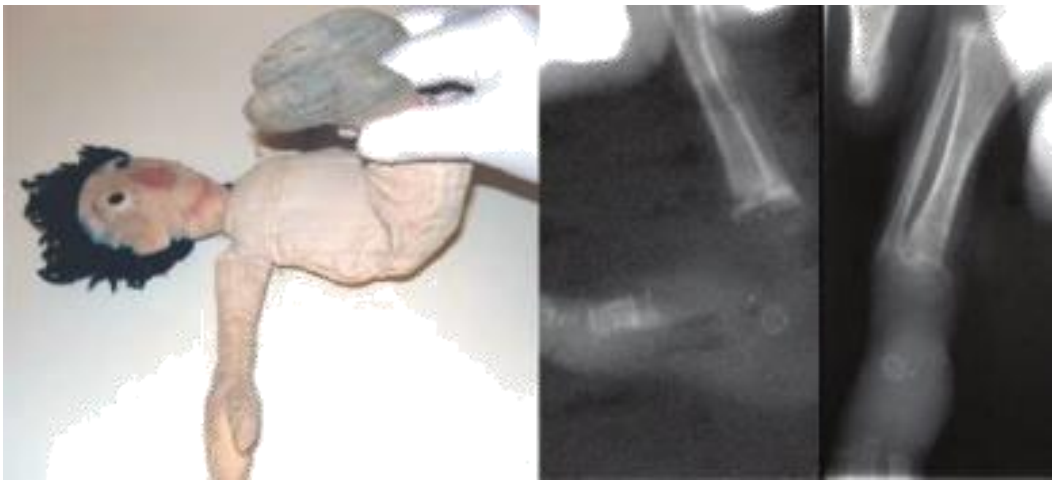

Image 3. Baby with fracture on the ankle caused by folding movement when changing the diaper (Brogdon et al. 2012)

According to Day et al. (2006), factors such as the age of the child less than 12 months and the presence of open fracture and head trauma provide important clues for clinicians to decide whether or not to perform skeletal analysis. Kemp et al. (2008) emphasized the need for suspicion of physical abuse as a distinctive diagnosis in the absence of a significant history of trauma or a disease that could lead to bone fragility and they stated that 25% to 56% of all fractures in children under one year of age are due to abuse. Although the possibility of accidental occurrence, traumas in non-mobile children should be evaluated by clinicians (Swoboda and Feldman, 2013).

Taitz (1991) defined the findings that could be evidence of child abuse on the basis of unexplained fractures in these cases, as a result of the evaluation of 22 infants and children who are subject to child protection cases or who are considered to be injured by their parents (Table 3). Kemp et al. (2008) compiled major types of fractures associated with child abuse (Table 4). Evaluating these data together can be a guide in many cases of child abuse.

Table 3. Evidence of child abuse in children and infants with unexplained fractures (Taitz 1991)

Brain damage
Multiple evidence of abuse and neglect
Subdural haemorrhage
Facial bruises and torn frenulum
Multiple bruises and oral injury
Multiple bruises
Previous bruising suggestive ofnon-accidental injury
Neglect
Confession by perpetrato
Fractures only

Table 4. Characteristics of some fracture types associated with suspicion of child abuse (Kemp et al. 2008)

Multiple fractures due to physical abuse are more common than non - abusive trauma injuries.
A child with multiple rib fractures has a 7 in 10 chance of having been abused.
Multiple rib fractures are more common than non-abusive fractures.
A child with a femoral fractures has a 1 in 3-4 chance of having been abused
Abuse-induced femur fractures are more common in children who have not yet begun to walk.
A child aged under 3 with a humeral fracture has a 1 in 2 chance of having been abused.
Mid-shaft fractures of the humerus are more common in abuse than in non-abuse, whereas supracondylar fractures are more likely to have non-abusive causes
An infant or toddler with a skull fractures has a 1 in 3 chance of having been abused
Parietal and linear skull fractures are the most common skull fractures in abuse and non-abuse cases.
There is no significant difference in the distribution of complex skull fractures between cases of abuse and non-abuse cases.

Case Studies

Case 1

A child skeleton was found near the house of parents suspected of killing their three-year-old daughter. The dental developmental stage and long bone lengths of the skeleton found were between 2-3 years old. Skeletal remains are well preserved and traumas in long bones have begun to heal. Subperiostal lesions observed in the skeleton indicate that the child is exposed to severe antemortem traumas (Image 4). Asymmetric distribution of lesions and different healing stages of these lesions confirm chronic child abuse (Walker et al., 1997).

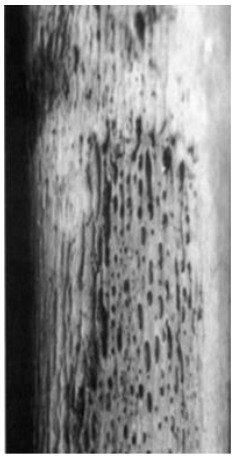

Image 4. Sharp edge appearance on the fibula, showing subperiostal bone formation and recent healing. Some lesions have been caused by postmortem damages (Walker et al. 1997)

Case 2

While searching for a child who has been missing for five years, the police have reached the partially skeletal remains of a three-year-old child in the trunk of the family car. The child's family first said that the child had fallen in the bath, had died because of hitting his head. Although they said they had buried the child, the police had reached the skeleton remains and proved that the child had been in the trunk of the car for many years. The cause of death could not be determined from the remains analyzed at autopsy. Phil Walker was an expert in both the forensic and bioarchological contexts of this issue. Therefore, his views were needed for the evaluation of the remains (White et al., 2012: 508).

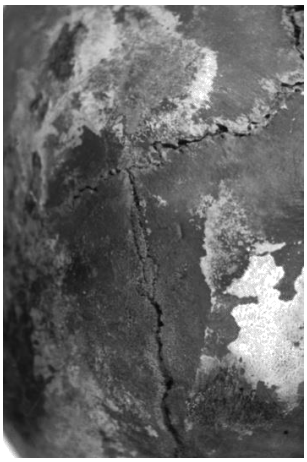

Image 5. Posteroinferior view of the cranium. The vertical fissure is a partially healed fracture of the occipital. When this fracture was examined closely, two healing stages were observed showing that the child was injured at least one month before his death. Photo courtesy of Phil Walker (White et al. 2012: 509)

As a result of dental and skeletal analyzes, it was determined that the child was subjected to trauma in the months before his death and these traumas were coincided with child abuse. Multiple injuries and different healing times were also detected (Image 5). This showed that the traumas were not accidental. As the existing osteological evidence proves longstanding physical abuse, prosecutors judged the child's parents with second-degree murder (White et al., 2012: 512).

Case 3

A mid-diaphyseal fracture was detected in the right humerus of a 7-month-old infant in the St. Oswald's Priory in Gloucester. This fracture was evaluated as a strong indicator of possible child abuse. The lamellar callus around the diaphysis fracture shows that the baby has survived for several weeks (Image 6). In addition, rickets, a metabolic disease caused by vitamin D deficiency, was diagnosed in this infant. Humerus fractures raise suspicion of child abuse even in the presence of rickets (Manifold, 2012). The fracture did not correspond with accidental fractures according to the age group of the case.

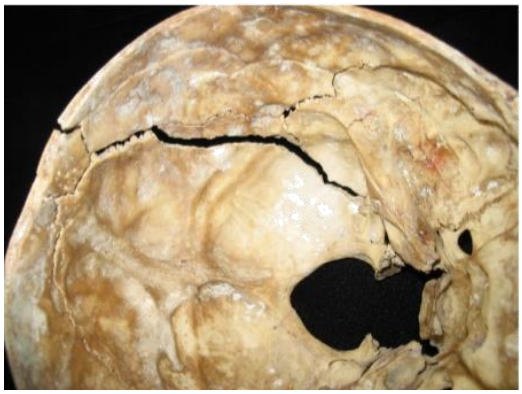

Image 6. Mid-diaphyseal humeral fracture with callus (Manifold 2012)

Case 4

In South Africa - Gauteng Province in 2004, 3 and a half year old boy died (Image 7). The child died in the care of his stepfather, and the stepfather gave incoherent statements and he said the boy was injury by falling in the bathroom. In the autopsy, soft tissue examinations were completed, but the child was buried without X-ray examination. About a year later, prosecutors in this case asked for the opening of the grave for the evaluation of the remains. It has been concluded that the child with severe head trauma has been subjected to repeated abuse for a long period of time. Stepfather and biological parents have been charged with ill-treatment and child neglect (Steyn, 2011).

Image 7. Close-up view of the cranial fracture that was the probable cause of death – Superior view (Steyn 2011)

Discussion

When forensic anthropology is mentioned, most researchers and even forensic anthropologists think about age and sex estimation studies. However, forensic anthropology is a much more comprehensive branch of science and therefore it must be in close contact with different disciplines and open to new techniques and developments.

In forensic anthropological cases and in medical applications based on skeletal analyzes, help from the opinions and suggestions of forensic anthropologists play an important role in the reliability and validity of the results. In this study, a more specific subject was compiled, unlike traditional fields of forensic anthropology. It has been mentioned how forensic anthropologists have contributed to child abuse cases. The use of forensic anthropological approaches in such cases seems to offer advantageous scientific results.

This study is expected to contribute to the literature by creating awareness about the relationship between forensic anthropology and different disciplines. It is also aimed to bring on the agenda the present studies on the subject.

Conclusion and Recommendations

Changes and deformations in the skeleton to identify physical findings of child abuse provide important data by providing primary or complementary indicators according to the condition of the case under investigation. In some cases, the views of pathologists and radiologists may be insufficient in the analysis of skeletal data. Forensic anthropologists are competent in skeletal development, skeletal biomechanics, fracture and trauma types. For this reason, forensic anthropologists can explain whether skeletal findings are related to physical abuse. Thus, forensic anthropological viewpoints lead to abuse researchers.

Radiographic techniques have an important place in the analysis of physical abuse evidence. In addition, new techniques can be developed. Child abuse has also been evaluated not only for modern populations but also for past human communities. Comparative analyzes can be diversified by supporting such studies.

Interdisciplinary approaches are frequently assessed for reliable analysis of evidence in the case of forensic cases. Child abuse is an important issue not only for medical professionals, but also for researchers working in the field of child protection. Although the skeletal traumas related to child abuse are evaluated in terms of guiding the clinicians' practice in most of the studies, they also shed light on the forensic anthropological aspects. Therefore, forensic anthropological perspectives are needed in cases of physical abuse in which the findings of the skeleton are evaluated.

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