

**Pattern of Skeletal Injuries in Physically Abused Children**

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**Objective:** The aim of this study is to identify the frequency and patterns of skeletal injuries among victims of child abuse in Bahrain.

**Design:** Retrospective.

**Setting:** Child Protection Unit at Salmaniya Medical Complex.

**Method:** Child's characteristics, type of skeletal injuries, location, pattern, radiological findings, and associated other injuries of 36 children were reviewed. Data management and analysis was done using SPSS for Windows, version 18.

**Result:** Thirty-six children with skeletal injuries resulting from child physical abuse were seen from 1991 to 2009. Twenty-three (64%) were males and 13 (36%) were females; the mean age was 3.8 years. Twenty-three (64%) were  $\leq 3$  years old. Multiple fractures were documented in 19 (53%) children. Bone fracture types and frequency were as follow: 10 (28%) affecting the femur, 9 (25%) skull, 8 (22%) humerus, 6 (17%) rib, 4 (11%) radius, 4 (11%) ulna and 2 (6%) tibia. Other bones less frequently affected were mandible, nasal bone, vertebral, metatarsals, and calcaneus fractures. In addition, other injuries included slipped femoral epiphysis, large bilateral hematoma in vastus lateralis, and full thickness tendon Achilles tear.

Hundred percent of rib, ulnar, radial and tibial fractures were in children under one year old. In addition, 7 (78%) of skull fractures, 5 (62%) of humerus fractures, and 5 (50) of femur fractures were under one year old. Six (67%) skull fractures involved the parietal bones, 4 (44%) were linear, 3 (33%) crossed sutures line, and 4 (44%) were associated with suture diastases. Five (83%) rib fractures involved posterior ribs.

**Conclusion:** Most of the abusive fractures occurred in infants and toddlers and

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**the commonest were femur, skull, humerus and rib fractures. The predominant findings supportive of child abuse were younger age, multiple fractures, and posterior rib fracture. Further research is needed to compare the pattern of childhood abusive fractures with fractures caused by accidental trauma, metabolic and chronic bone disorders.**

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Child physical abuse (CPA) is a serious social and public health problem<sup>1</sup>. It is detrimental to the children's physical and mental wellbeing<sup>2,3</sup>. The most common physical indicator of CPA is skin manifestations such as bruises, cuts, abrasions and burns; the second is skeletal injuries. However, the exact frequency of skeletal injuries is variable in different studies and it is probably due to method of studies' design, inclusion/exclusion criteria, and the study period. In a study from Bahrain, fractures were the second most common indicator of CPA and were documented in 25% of the victims<sup>4</sup>. A similar trend of decline in abusive fractures from 22.5% to 10.8% over 24-years-period was documented in a large cohort study from the USA<sup>5</sup>.

However, skeletal injuries and especially fractures are also common childhood injuries and caused mainly by accidents such as falls, sports injuries and road traffic accidents<sup>6</sup>.

Unfortunately, in many children, fractures are inflicted by caretakers and there are no specific diagnostic features of 'abusive fracture'; therefore, many victims go unrecognized<sup>7</sup>. Therefore, differentiating between accidental and abusive fractures is essential to protect the child from further abuse and to respect the parents' rights for privacy and unjustified accusation, which can be very traumatic and disruptive to the family.

Studying the characteristics of inflicted skeletal injuries in each country and comparing it with published studies is important to improve the understanding and diagnosis of abusive skeletal traumas. At the present time, there is lack of information about the pattern of fractures among abused children in Bahrain.

The aim of this study is to identify the frequency and patterns of skeletal injuries among victims of child abuse in Bahrain.

## **METHOD**

The CPU reviewed all the records of child abuse cases from January 1991 to December 2009. Out of 804 child abuse and neglect, 36 children were identified to have abusive skeletal injuries. In addition, all the available radiographs (skeletal films, CT scans and MRI) were reviewed by the research team led by the radiologist. The key elements documented were the child's age, gender, fractures locations, types, results of investigations and other associated non-skeletal injuries.

None of the children had a plausible history of major trauma and none had CPR before diagnosing the fractures. All cases of accidental trauma or those due to metabolic diseases such as osteogenesis imperfecta, osteopenia of prematurity and rickets were excluded. SPSS version 18 for Windows was used for data management and statistical analysis. This study is based on the review of medical records, radiographs and the identity of patients is kept strictly confidential. Only children who sustained skeletal fracture as a result of child abuse were included in the study. Health Research Committee at Salmaniya Medical Complex has approved the study.

## RESULT

Thirty-six records of children who fit the profile of abused were reviewed. As shown in table 1 the majority of victims were males 23 (64%). Average age was 3.8 years and 23 (64%) of the patients were three years or less. Multiple fractures were documented in 19 (53%) children. As shown in table 2, the most common fractures were femur and skull fractures. Skull fractures (figure 1) were documented in 9 (25%) children and 7 (78%) were under one year of age. Out of the nine skull fractures, 6 (67%) involved the parietal bone, 3 (33%) the occipital bone and 1 (11%) the frontal bone. Skull fractures were simple linear in 4 (44%), depressed in 1 (11%), crossed sutures line in 3 (33%) and associated with suture diastases in 4 (44%). Rib fractures were documented in 6 (17%) children; all were below one year of age. Rib fractures (figure 2) were multiple in the six patients and involved posterior ribs in five (83%). None of the patients underwent CPR before detecting the fractures.

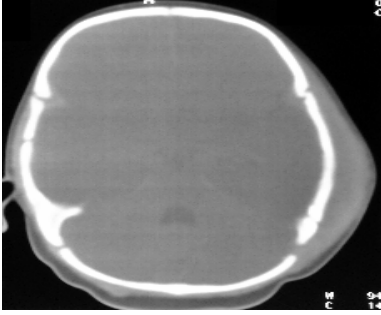
**Table 1: Children's Age and Gender**

Age	Gender
Average: 3.8 years (one day – 15 years)	Males: 23 (64%)
One year and below: 20 (56%)	Females: 13 (36%)
2-3 years: 3 (8%)	
4-6 years: 5 (14%)	
7-15 years: 8 (22%)	

**Table 2: Types of Bone Fractures and Victims' Age**

Type of Fracture	Number (%)	Age ≤ One Year Number (%)
Femur	10 (28)	5 (50)
Skull	9 (25)	7 (78)
Humerus	8 (22)	5 (62)
Rib	6 (17)	6 (100)
Radius	4 (11)	4 (100)
Ulna	4 (11)	4 (100)
Tibia	2 (6)	2 (100)
<b>Total</b>	<b>43</b>	

Some children had more than one fracture



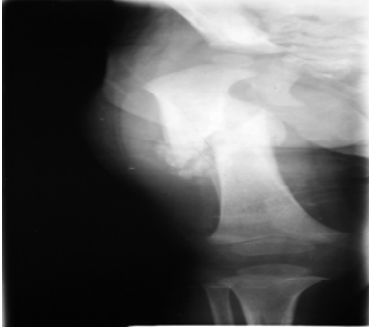
**Figure 1: Axial Plain CT Scan of the Brain Showing Fractures of Both Parietal Bones with Subgaleal Hematoma in the overlying Scalp and Mild Sutural Diastases**



**Figure 2: X-ray Chest Showing Multiple Posterior Rib Fractures Involving the 6<sup>th</sup>, 7<sup>th</sup>, and 9<sup>th</sup> Ribs**

Long bone fractures (Figures 3 and 4) were documented in 28 (78%) of the total skeletal injuries and involved all long bones except the fibula. The fractures were spiral in 3 (11%) and oblique in 6 (21%) with callus formation at presentation in 6 (21%). Children under one year had the following fractures: 5 (62%) humerus, 5 (50%) femur, 4 (100%) ulnar and radial bones. Subperiosteal new bone formation was found in 6 (21%). None of the patients showed the classical metaphyseal lesions of corner chip or buckle-handle fractures.

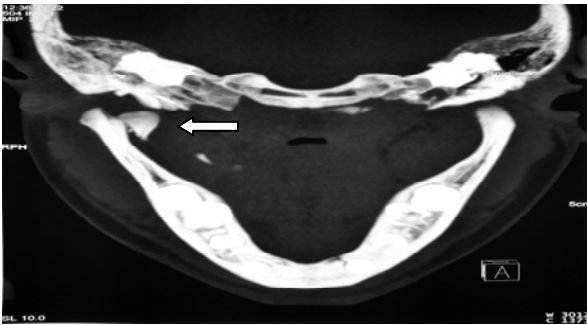
Other fractures were mandibular (Figure 5), nasal bone, metatarsal, and vertebral which were documented in one patient each. Calcaneus fracture was documented in two patients. In addition, large bilateral hematoma in vastus lateralis (quadriceps femoris) was documented in one patient and required surgical evacuation.



**Figure 3: Neglected Oblique Fracture of the Femur's Mid-Shaft with Some Mal-Alignment and overlap of the Fragments and Abundant Callus Formation**



**Figure 4: Healing of Transverse Fractures of the Distal Shaft of the Radius and Ulna with Callus Formation and Angulation of the Radius**



**Figure 5: Coronal CT Scan with 3D Reconstruction of the Facial Bones Shows Fracture of the Right Mandibular Condyle with Medial Displacement (white arrow)**

Full thickness tendon Achilles tear was seen in one child. Associated injuries were bruises in 21 (58%), head injuries other than simple skull fracture in 15 (42%), abdominal injury in 3 (8%), and thoracic duct injury leading to chylothorax in one patient (4%). Slipped femoral epiphysis was documented in a student who was asymptomatic and developed pain immediately after being violently hit by his teacher. The patient required surgical intervention with screw fixation of the right femoral epiphysis and neck.

## DISCUSSION

There is no gold standard diagnostic test or clinical features to distinguish inflicted from accidental musculoskeletal injuries. In clinical setting, several indicators can be used to differentiate the two: medical and family history, developmental age, multiple fractures or those of different ages, associated disorders or injuries, and detailed physical examination looking for other indicators of abuse.

In this study, 64% of the abused victims were three years old or less. Several other landmark studies had established that age is a major determinant in predicting inflicted from accidental fractures in children; younger children are at more risk of sustaining inflicted fractures while older children are at more risk of accidental fractures<sup>8-11</sup>.

Another indicator is the presence of single or multiple fractures with or without other systems involvement. In this study, 53% of the victims had multiple fractures. A study found a highly significant association between multiple fractures and abuse, 74% of abused versus 16% of non-abused children had two or more fractures<sup>9</sup>.

In this study, rib fractures represented 17% of the skeletal injuries. All victims were under one year of age and all had multiple ribs involvement. Several other studies showed that rib fractures are strongly suggestive of abuse especially among infants and tend to have multiple ribs involvement which could be at any location on the rib, unilateral or bilateral<sup>8,12-15</sup>.

Some studies have shown that anterior rib fractures are significantly more common in abused, and lateral fractures were more common in non-abused children<sup>12,14</sup>. In this study, posterior rib fractures were documented in 83% of the patients. Six other studies have shown that posterior rib fractures were predominantly due to abuse<sup>12,16</sup>. In addition, it is important to recognize that, although it is rare, posterior rib fractures were reported after difficult and traumatic deliveries<sup>17,18</sup>.

Identifying posterior rib fractures on anteroposterior or lateral X-ray might be difficult and the oblique view of ribs has been found to be significantly better<sup>12,19</sup>. Therefore, the oblique view of ribs is currently recommended by the American Academy of Pediatrics to be part of the standard views of skeletal survey in suspected abuse in children under two years of age<sup>19,20</sup>.

Cardiopulmonary resuscitation (CPR) has been debated as a cause of rib fractures. A recent systematic review found anterior rib fractures in only three out of 923 children undergoing CPR<sup>21</sup>. Therefore, rib fractures are rare complication of CPR in children, and when they do occur, they are likely to be anterior<sup>21</sup>. In our study, no child had CPR prior to presentation. Any child with rib fracture without underlying metabolic bone disease or dysplasia or a clear history of complicated delivery or major trauma, child abuse should be suspected especially in infants.

In this study, skull fractures were identified in 28% of abused victims. In general, skull fractures are common childhood injury, 80% of accidental and 88% of abused skull fractures reported to occur in infants less than one year<sup>22</sup>.

In this study, 67% of skull fractures involved the parietal bone and were linear in 44%, crossed suture lines in 33% and were associated with suture diastases in 44%; the finding is similar to other studies<sup>23,24</sup>. However, multiple, bilateral fractures or those that crossed suture lines were more common in abused children<sup>23</sup>. The belief that depressed, diastatic, and growing fractures were more common in abused than in non-abused is being strongly challenged<sup>25</sup>.

Femoral fractures represented 28% of the total fractures and (36%) of long bone fracture. Fifty percent of the affected were under one year. This is similar to the findings of other studies<sup>22,26</sup>. The commonest fracture location in both abused and non-abused children is the mid-shaft of the femur<sup>9,27</sup>. In more than 18 months-age-group, the risk of femur fractures was 3.3 times higher in the accidental trauma group than in the child abused group<sup>8</sup>.

In this study, the fractures were spiral in 11% and oblique in 21%. In another study, spiral fracture was the most common femoral fracture in abused children under 15 months and no significant difference existed between abused and non-abused children older than 15 months<sup>28</sup>. None of the patients in this study showed the classic metaphyseal chip fractures despite the commonly held belief that the classical metaphyseal lesions are pathognomonic of abuse<sup>29,30</sup>. Furthermore, a recent study reported a complete distal femoral metaphyseal fractures caused by abuse<sup>31</sup>.

In this study, tibial fractures were documented in 7% of the patients. A study indicated that 96% of tibial fractures in children under 18 months were caused by abuse<sup>32</sup>. Another study identified abusive tibial fractures in 31.1% of hospitalized children<sup>33</sup>.

In this study humeral fractures were identified in 22% of the patients; sixty-two percent were less than one year and 75% were less than 18 months, none had supracondylar fractures. The pattern and age affected is similar to other studies<sup>9,15,34-36</sup>. Furthermore, a recent study reported supracondylar fracture in an abused infant<sup>37</sup>.

In this study, radial and ulnar fractures, each, were documented in 11% of the patients. Another study showed an overall rate of 25% of radial and ulnar fractures in abused children<sup>38</sup>.

In this study, metatarsals fracture was documented in one patient and calcaneus fracture in two patients and none in the hands. One patient with calcaneus fracture was one month old. Fractures of the metatarsals have been reported in a child as young as 6 months<sup>39</sup>. Another study reported bilateral fractures of the hands and feet in more than two-third of the infants<sup>40</sup>.

In this study, mandibular fracture was seen in one patient. Mandibular fractures were rarely associated with other injuries and occurred in all age groups<sup>41</sup>.

In this study, one patient had slipped femoral epiphysis. Although slipped femoral epiphysis is typically attributed to hormonal changes and obesity, in that patient the history of trauma was not disputable. Other studies reported hip and pelvic fractures in association with several other serious injuries<sup>42,43</sup>. The study limitations are related to the constraints of being a retrospective study.

## CONCLUSION

**Most abusive fractures in this study occurred in infants and toddlers; the commonest were femur, skull, humerus and rib fractures. The indicators of child abuse were younger age, multiple fractures, and posterior rib fracture. Physical abuse should be considered when an infant or a toddler presents with a fracture, especially in the absence of a history of metabolic bone disease or a clear history of significant trauma. Further research is needed to compare the patterns of childhood abusive fractures with accidental trauma, metabolic and chronic bone disorders fractures.**

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**Competing Interest:** None, **Sponsorship:** None

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**Ethical approval:** Health Research Committee at Salmaniya Medical Complex has approved the study

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