

# Patterns of fractures in accidental and non-accidental injury in children: a comparative study

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## Abstract

The incidence and pattern of fractures in children who had been abused were compared with those of fractures sustained by children of similar ages in whom abuse had been excluded. From 1976 to 1982 there were 35 children with fractures resulting from child abuse, and all were aged under 5. Of the 826 children in the control group, seen from January to June 1981, 85% were aged over 5. Abused children were much more likely to have multiple fractures ( $p<0.001$ ) and bruising of the head and neck ( $p<0.001$ ). Fractures of the ribs were common in children who had been abused, and their presence, in the absence of major chest trauma, strongly suggested that abuse was occurring. Injuries to the long bones were invariably spiral or oblique fractures or subperiosteal new bone formation—both “gripping or twisting” injuries. Spiral fracture of the humeral shaft was significantly more common ( $p<0.001$ ) in the group of abused children. Classic metaphyseal chip fractures were uncommon.

One child in eight aged under 18 months who sustains a fracture may be a victim of child abuse.

## Introduction

Since Kempe *et al* first published their description of the battered child syndrome in 1962 doctors have learnt to recognise obvious cases of child abuse.<sup>1</sup> As in other branches of medicine, descriptions of the gross disease allow it to be diagnosed before more serious manifestations develop. Evidence from studies by the National Society for the Prevention of Cruelty to Children suggests that the rate of physical injury has increased from 0.46/1000 children in 1976 to 0.63/1000 in 1982 but that the proportion of serious injuries has fallen from 17% to 10%.<sup>2</sup>

Since 1973, when area review committees were set up throughout the United Kingdom, much work has gone into the management of child abuse. The multidisciplinary approach has taught many doctors about the roles of different agencies. After a case conference it is usually social services departments or the National Society for the Prevention of Cruelty to Children that plays the major part. They institute care proceedings, arrange fostering, and have the resources to organise institutional care or therapeutic programmes in the home. The role of doctors is less clear.<sup>3</sup> They may be required to give evidence in court; paediatricians will probably follow up the family in the outpatient clinic; general practitioners and their health visitors will review the families in their own home; clinical medical officers will follow up in clinics or schools; and psychiatrists may be seeing the parents.

The main role of doctors, however, is in diagnosing child abuse; investigations are started by them in perhaps half of the cases. They are often asked to do this only on the basis of the injuries sustained. In gross cases this may not be difficult, but in earlier and less severe cases it is almost impossible without a great deal of further

information about the family history, delay in seeking medical advice, adequate explanation, and other well documented factors.<sup>4</sup>

In 1969 Skinner and Castle reported that half of the children confirmed as having been abused had been seen previously with an injury.<sup>5</sup> Experience from case conferences suggests that this could still be true. Junior medical staff in accident units and general practitioners might not have much experience in dealing with non-accidental injury. Simple indicators that might alert nursing and medical staff to the possibility of abuse would be helpful. In a previous paper from this unit the pattern of soft tissue injury was compared in abused and normal children,<sup>6</sup> but there has not been a study that compared the pattern of fractures in these two groups. We defined the incidence and pattern of fractures sustained in children who had been abused by comparing them with those of fractures in children of similar ages in whom abuse had been excluded.

## Subjects and methods

Children with fractures due to non-accidental injury were identified from the records of the Nottinghamshire National Society for the Prevention of Cruelty to Children special unit, which has maintained the child abuse register for the county since 1976. Only those children whose fractures were proved to be the result of child abuse were included; those placed on the register of children at risk because a case conference could not confirm suspicions of abuse were excluded from the study. Children living outside the boundaries of Nottingham Health District were also excluded.

The control group comprised all children aged 12 or under who presented with a fracture to the accident department of the University Hospital, Nottingham, from 1 January to 30 June 1981 and in whom abuse was excluded. These children were identified from Hospital Activity Analysis, fracture clinic records, and accident unit records. The University Hospital is the sole accident unit in Nottingham, and children living outside the boundaries of Nottingham Health District were excluded.

Data were recorded on a standard form and included age, sex, number of fractures, and any associated injuries. Children in both groups were divided into three sets by age: infants (0-18 months), toddlers (19-60 months), and schoolchildren (>60 months). Fracture pattern was recorded by bone, site (proximal epiphysis, proximal metaphysis, shaft, distal metaphysis, and distal epiphysis), and type (transverse, oblique, spiral, comminuted, greenstick, linear, or depressed). The coding convention allowed classification of epiphyseal injuries according to Salter and Harris.<sup>7</sup> The results were analysed using subprograms of the statistical package for the social sciences on an ICL 2900 mainframe computer.<sup>8</sup> Statistical analysis was performed with the  $\chi^2$  test, with Yates's correction to allow for small numbers.

## Results

Under the strict criteria of physical injury as defined by the National Society for the Prevention of Cruelty to Children,<sup>2</sup> about 200 children are placed on the Nottinghamshire child abuse register annually. From 1976 to 1982 there were 35 children, living within the boundaries of Nottingham Health District, who sustained fractures as a direct result of child abuse. These children made up the non-accidental injuries group. There were a further 15 children, living in Nottingham, in whom child abuse was only suspected as the cause of fracture, and these children were excluded from the study group.

During the first six months of 1981, 854 children attended the accident department of the University Hospital, Nottingham, because of a fracture. Of these children 28 were excluded because their history was thought to be inconsistent with the injury sustained. Subsequent investigation confirmed non-accidental injury in only two of these children, and they were included

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in the non-accidental injuries group. Thus 826 children formed the control (accidental injuries) group.

Table I shows the age distribution of the children in each group. No child over the age of 5 had a fracture resulting from child abuse. There were therefore 116 children under 5 in the accidental injuries group available for direct comparison. The non-accidental injuries group comprised 24 boys and 11 girls, and the accidental injuries group comprised 59 boys and 57 girls; the preponderance of boys in the non-accidental injuries group was not significant ( $\chi^2=3.41$ ,  $df=1$ ).

TABLE I—Distribution of children by age\* (figures are numbers (%) of children)

Age (months)	Non-accidental injuries group	Accidental injuries group
<18	28 (80)	19 (2)
19-60	7 (20)	97 (12)
61-155	—	710 (86)
Total	35	826

\* $\chi^2=403$ ,  $df=2$ ,  $p<0.001$ .

The census data for Nottingham showed that in 1981 there were 10 989 children aged under 18 months and 23 564 children aged 19-60 months; thus the estimated annual incidence of fractures from child abuse (based on an average of five cases a year) was 4/10 000 for children aged under 18 months and 0.4/10 000 for children aged 19-60 months.

In the non-accidental injuries group nine children sustained one fracture, seven sustained two, and 19 children three or more. No child in the accidental injuries group had more than two fractures: 97 children had only one fracture and the other 19 had two fractures. This difference was significant ( $\chi^2=76.0$ ,  $df=2$ ,  $p<0.001$ ). Table II shows the association of these fractures with other injuries in both groups. Of the 25 children in the non-accidental injuries group with significant associated bruising, 18 were injured on the head and neck (72%). Among the miscellaneous injuries in the non-accidental injuries group there was one child with a cigarette burn.

TABLE II—Association of fractures with other injuries\* (figures are numbers of children)

Other injuries	Non-accidental injuries group	Accidental injuries group
None	6	99
Significant bruising	25	1
Miscellaneous	4	16
Total	35	116

\* $\chi^2=95.9$ ,  $df=2$ ,  $p<0.001$ .

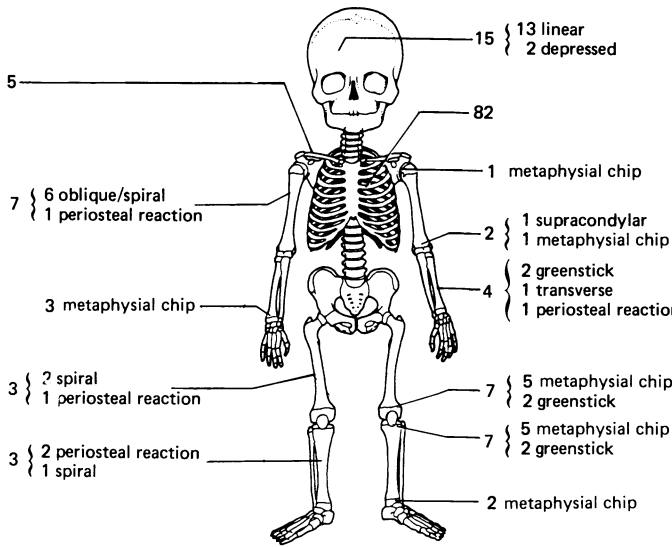


FIG 1—Site and type of fracture resulting from child abuse in infants.

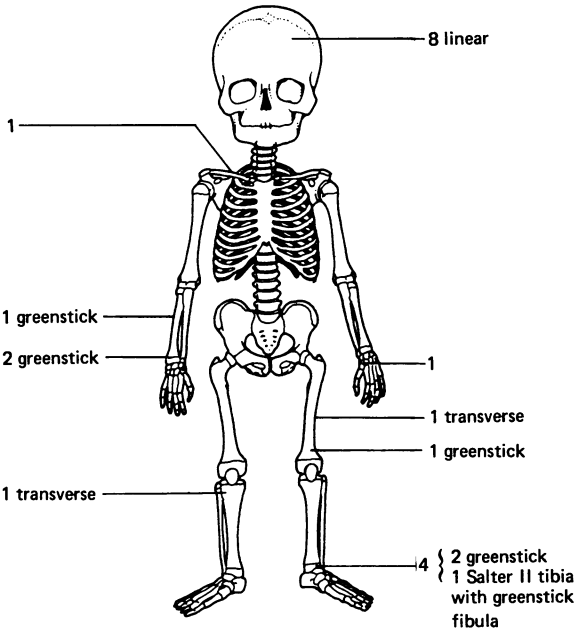


FIG 2—Site and type of fracture in normal infants.

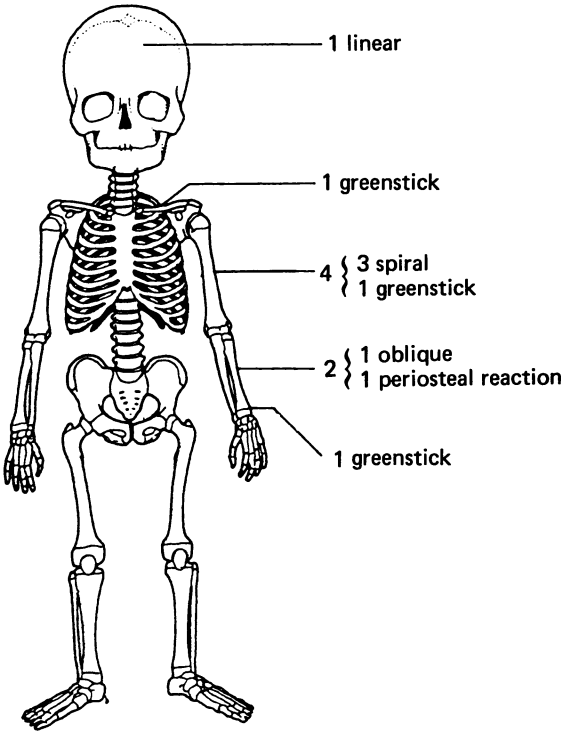


FIG 3—Site and type of fracture resulting from child abuse in toddlers.

Figures 1 and 2 show the site and type of fracture in infants and figures 3 and 4 the site and type of fracture in toddlers. Although fractures of the rib were the commonest fracture in children who had been abused, no child presented with this type of fracture alone; all had been diagnosed on skeletal examination of children in whom abuse had been suspected. The classical metaphyseal chip fracture was uncommon: there were only 17 fractures of this type seen in the non-accidental injuries group (11%). Long bone fractures resulting from child abuse are mainly indirect injuries: spiral fractures and periosteal new bone formation as a result of gripping or twisting injuries or metaphyseal chip fractures from traction injuries. Spiral fractures of the humeral shaft were seen in nine children in the non-accidental injuries group, but no child under 5 in the accidental injuries group sustained such a fracture, a difference that was significant ( $\chi^2=27.0$ ,  $df=1$ ,  $p<0.001$ ).

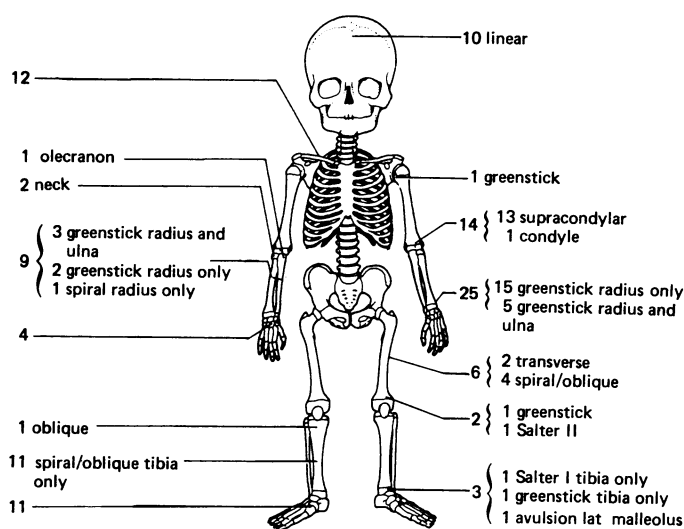


FIG 4—Site and type of fracture in normal toddlers.

In the non-accidental injuries group 12 children sustained 16 fractures of the skull, while in the accidental injuries group there were 18 children with 23 fractures of the skull. Such fractures in children who had not been abused were usually single, linear fractures of the parietal bone, while those resulting from abuse were more often multiple or complex and more likely to affect the temporal or occipital bones. Larger numbers, however, would be necessary to establish whether these differences were significant.

## Discussion

Although there have been previous descriptions of the fractures sustained after child abuse, in none of these studies was the population clearly defined, so incidences could not be calculated.<sup>9,11</sup> No previous study has compared the pattern of fracture in abused children with the pattern in normal children.

Although boys are more often subject to physical abuse than girls,<sup>2</sup> we found no significant difference in our series. This is in accordance with the findings of Akbarnia *et al*<sup>9</sup> and Kogutt *et al*,<sup>10</sup> and it thus appears that boys and girls are equally likely to sustain fractures due to non-accidental injury.

No child over 5 years of age had a fracture resulting from abuse, and 80% of fractures in abused children occurred when they were less than 18 months of age. This is in contrast to normal children, in whom 85% of fractures occurred over the age of 5. In a detailed study of the 826 normal children with fractures after accidental injury we have shown significant differences in incidence, aetiology, and pattern of fractures among infants, toddlers, and school-children as defined earlier (P Worlock and M Stower, unpublished). These age groupings seem to represent more logical stages in a child's development as well as reflecting differing risk factors. In that same study the annual incidence of fractures in children aged under 18 months was 34/10 000, and in children aged 19-60 months it was 96/10 000. In this series the incidence of fractures after non-accidental injury was 4/10 000/year in children aged under 18 months; this suggests that in Nottingham one child in eight in this age group with a fracture may be a victim of child abuse.

The presence of multiple fractures resulting from abuse has been previously recorded,<sup>9,12</sup> and these findings are confirmed by the present study. In an earlier study from Nottingham Robertson *et al* reported that soft tissue injuries of the face and neck were more common in abused children.<sup>6</sup> We have confirmed this finding, and

the association of a fracture and a soft tissue injury of the head and neck is strongly suggestive of child abuse.

Metaphyseal chip fractures, as classically described by Kempe *et al*,<sup>1</sup> have been reported to be very common in non-accidental injury.<sup>9,11,13</sup> We found that they account for only 11% of fractures resulting from abuse, and this has reinforced our clinical impression that these lesions are less common. We found fractures of the ribs to be very common after non-accidental injury: of 826 children in the control group, only one child had fractures of the ribs, and these resulted from severe blunt chest trauma in a road traffic accident. Fractured ribs have not previously been thought to be common in child abuse.<sup>10,11</sup> Smith *et al* suggested that this is because these fractures occur at the costovertebral junction and this area is difficult to visualise radiologically; they reported four cases of multiple costovertebral fractures resulting from abuse that were diagnosed with technetium bone scanning and recommended this technique.<sup>14</sup> Our experience suggests that the presence of multiple fractures of the ribs on skeletal survey in the absence of a history of major chest trauma is strongly suggestive of child abuse.

It has been suggested that if a fracture of the skull is present it may be possible to diagnose abuse from the fracture alone.<sup>15</sup> The characteristics of injuries resulting from abuse are multiple or complex fractures, damage to more than one bone, non-parietal fractures, and depressed and growing fractures. Although we found this trend in our cases, the difference was not significant, but this may have been because of our small numbers.

Child abuse cannot be diagnosed from the patterns of fractures alone. We hope that this study will give some guidance to those concerned in the initial assessment of injured children. If unusual patterns of fractures and associated injuries are seen a full and careful assessment by medical staff experienced in this work is essential.

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