

Interpretation of paediatric trauma

Introduction

Fractures in children differ from those in adults in a number of ways. The immature skeleton is more elastic resulting in incomplete fractures (torus and greenstick) as well as fractures without cortical disruption. In addition the periosteum is more elastic and thicker than in adults. Also children's bones heal quicker and remodel more readily. However, there are areas of structural weakness, which adults do not possess, in the epiphyseal growth plates and zones of cartilage hypertrophy. Therefore fractures at these sites are common.

This article will describe the common types and sites of paediatric bone injuries as well as giving a brief review of non-accidental injury (NAI).

Types of paediatric injuries

Greenstick fracture

This fracture is characterized by a break in one cortex and bending of the other (Figure 1) and usually results from an angulation force.

Torus fracture

This is a variant of the greenstick fracture where buckling of the cortices is seen (Figure 2). This type of injury results from a longitudinal compression force. The commonest sites for this injury are the distal radius and ulna. Angulation is usually not seen with this injury.

Plastic bowing fracture

In this type of injury bending of the bones is seen without cortical break (Figure 1). Subtle fractures may be missed initially and only become apparent when new periosteal bone forms along the shaft.

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Figure 1. Anteroposterior (AP) and lateral radiographs of the forearm showing a greenstick fracture of the ulna (arrow) and plastic bowing of the radius.

Growth plate injuries: Salter–Harris classification

The epiphysis, epiphyseal plate and metaphysis is involved in up to 15% of fractures of the long bones in children. The epiphyseal plate is weaker than the adjacent ligaments and tendons and so is commonly involved in injuries (Figures 3–6). The complication of premature epiphyseal fusion may lead to angulation deformities (if part of the growth plate is involved) or limb shortening.

The Salter–Harris classification of epiphyseal injuries should be known and

Figure 2. Torus fracture (arrow) of the distal radius seen as buckling of the cortex.



Figure 3. Salter–Harris type III fracture (arrow) of the distal tibial epiphysis.

applied (Table 1, Figure 7). The type II fracture is the most common type. As a rule of thumb the lower the Salter–Harris classification number the better the prognosis.

Figure 4. Salter–Harris types I and II fractures of the distal phalanx of the index finger (arrow). The type I injury is manifest as slip of the epiphysis.



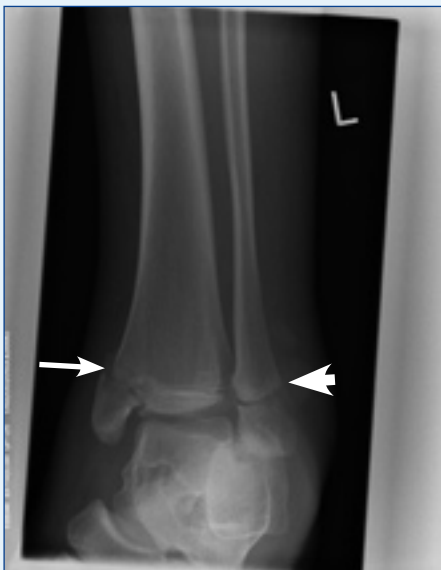


Figure 5. Salter–Harris types II and IV fractures of the ankle. The type IV injury is seen of the medial malleolus (small arrow) and the type II injury of the lateral malleolus (large arrow).

Common paediatric injuries

During birth (most frequently in breech deliveries) fractures and dislocations can occur particularly in the skull and clavi-

Figure 6. Salter–Harris type II fracture of the base of the proximal phalanx of the thumb (arrow).



Table 1. Salter–Harris classification

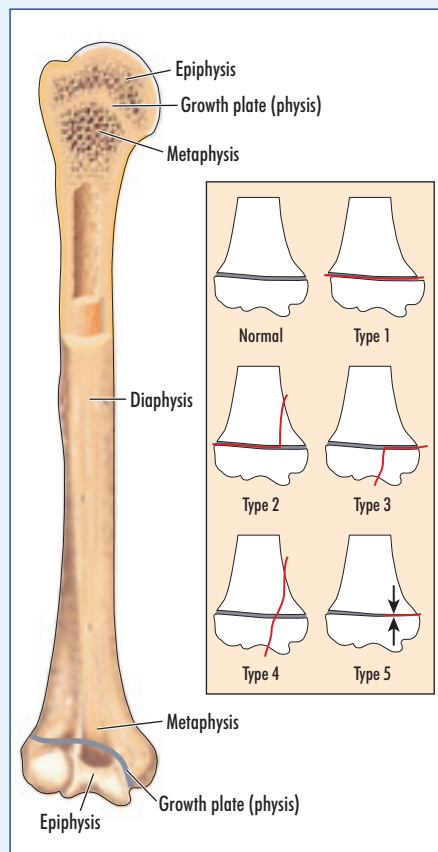
Type I	Separation of the epiphysis with the fracture confined to the growth plate (6%). Examples include apophyseal avulsion and slipped capital femoral epiphysis. This has a good prognosis regardless of site
Type II	Fracture through the growth plate extending through the metaphysis (75%). This type of fracture is usually seen at the distal radius. It has a good prognosis but may result in minimal shortening
Type III	Fracture through the growth plate extending through the epiphysis (8%) and into the joint space. The prognosis is fair
Type IV	Fracture extending from the articular surface of the epiphysis (i.e. involving the joint space) through the growth plate and metaphysis (10%). There is an increased likelihood of deformity and angulation
Type V	Compression of the growth plate (1%). The prognosis is poor with growth impairment very common

The prognosis is worse in the lower limb independent of Salter–Harris type

cles. During the first 2 years fractures are rare and may raise the possibility of NAI. After the age of 2 years, the radius is the most commonly fractured long bone followed by the phalanges and metacarpals. Supracondylar and Toddler’s fractures are common in the 2–5-year age group.

Specific paediatric trauma will now be discussed.

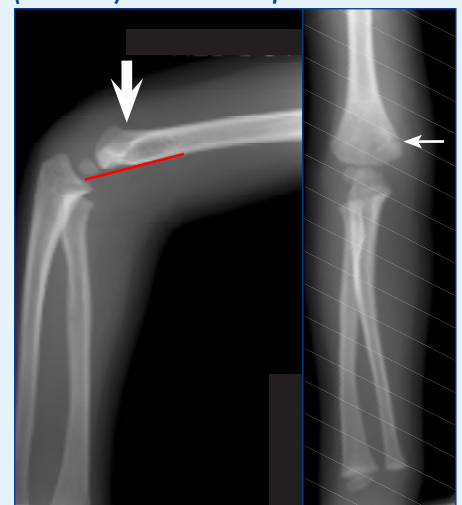
Figure 7. Salter–Harris classification of epiphyseal plate injuries.



Supracondylar fractures

Supracondylar fractures are the commonest fractures in children, caused usually by a fall on an outstretched hand. Usually a transverse fracture passes just proximal to the capitellum and trochlea, with the distal fragment often posteriorly displaced. On a lateral view a line traced along the anterior cortex of the humerus should bisect the capitellum such that one third lies anterior to this line. In a supracondylar fracture posterior displacement of the distal fracture fragment results in the line lying anterior to the capitellum (Figure 8). Undisplaced fractures are often missed, but a positive posterior fat pad sign is almost always present.

Figure 8. Anteroposterior (AP) and lateral radiographs of the elbow showing a supracondylar fracture (arrow). Note that a line drawn along the anterior humeral surface would pass anterior to the capitellum. The presence of a posterior fat pad (thick arrow) is indicative of a joint effusion.



Epicondylar elbow injuries

Epicondyle injuries are also common, and can be extensive, involving also the capitellum, trochlea and distal humeral metaphysis. Internal (medial) epicondylar epiphyseal avulsions occur in relation to elbow dislocations (Figure 9). The avulsed epiphysis is usually displaced inferiorly, but it may lie intra-articularly. In this situation it may be misinterpreted as being one of the other ossification centres. Remembering the normal sequence of ossification will assist diagnosis and is denoted by the acronym 'CRITOL' (Capitellum 1 year, Radial head 3 years, Internal (medial) epicondyle 5 years, Trochlea, 9–11 years, Olecranon, 9–11 years and Lateral (external) epicondyle 9–11 years).

If the trochlear epiphysis is present, the internal epicondyle epiphysis must also be present on the radiograph and may be avulsed. Positive fat pad signs may help, and in difficult cases a radiograph of the

Figure 9. Anteroposterior (AP) elbow radiograph showing an internal epicondylar epiphyseal avulsion. The avulsed epiphysis is displaced inferiorly (black arrow), and occurred as a result of sudden valgus stress.



uninjured side may be of use. Fracture of the lateral epicondyle is the second commonest childhood fracture (Figure 10).

Pulled elbow (nursemaid's elbow)

Pulled elbow occurs in children between 1 and 4 years of age, and occurs when there is a sudden pull on the pronated extended arm, such as when the child is suddenly lifted by the hand. It occurs as a result of momentary distraction of the radiocapitellar joint, producing subluxation of the radial head through the angular ligament. Reduction is achieved by supinating the forearm. Radiographs are usually normal.

Avulsion fractures

Fractures of the apophyses (secondary ossification centres) at the tendinous insertions are usually seen in young athletes. Typically there is irregularity at the site of injury with avulsed pieces of bone of variable size. Common avulsion sites and the tendon insertions are the anterior superior iliac spine (sartorius) (Figure 11), anterior inferior iliac spine (rectus femoris), greater trochanter (gluteal muscles), lesser trochanter (psoas), ischial tuberosity (hamstrings) and pubic tubercle (adductors).

Toddler's fracture

This is caused by falling with one leg stationary (e.g. between the bars of a cot) and results in a spiral fracture of the tibia (Figure 12).

Figure 10. Anteroposterior (AP) elbow radiograph showing a lateral epicondylar fracture (arrow) as part of a supracondylar fracture.



Figure 11. Old avulsion of the left anterior superior iliac spine in a mature skeleton (arrow).

Tibial stress fractures

The proximal tibial shaft is the most common site of stress fractures in children. They are seen at 10 days as a dense sclerotic band across all or part of the shaft followed by variable periostitis. The sclerotic change may be replaced by a radiolucent band. Magnetic resonance (MR) imaging and nuclear scanning will detect the abnormality as early as 3 days post onset of symptoms.

Slipped capital femoral epiphysis

Hip pain is the commonest cause of paediatric orthopaedic admissions in the UK. The majority of these children are diagnosed as having a transient synovitis (irritable hip) which is a self-limiting condition, seen throughout childhood, associated with an effusion and thought to be viral in aetiology.

Other more serious conditions need to be excluded. These include septic arthritis, inflammatory arthritis, Perthe's disease (idiopathic avascular necrosis which is commoner in boys and rare over the age of 7 years) and a slipped capital femoral epiphysis (SCFE). Remember that hip

Figure 12. a. Anteroposterior (AP) and (b) lateral radiographs of the leg showing a Toddler's fracture (arrow) which is best seen on the AP view.



pain may be referred to the knee in children so X-ray the hip if necessary as well as the knee in children presenting with knee pain.

SCFE is the commonest adolescent hip disorder with boys affected 2–3 times more than girls. SCFE is a Salter–Harris type 1 fracture. Classically the condition occurs in obese boys at the age of 10–17 years. The condition is bilateral in 20–40% and therefore all patients should be closely followed up because about 25% develop a slip of the contralateral hip within 18 months of the first slip. The slip is usually posteromedial with decreased epiphyseal height, widening and irregularity of the growth plate on the AP (anteroposterior) film. A line (Klein’s line) drawn along the lateral femoral neck should intersect the capital epiphysis so that one-sixth of it lies lateral to the line. In 10% of cases no abnormality is present on the AP film but the frog-leg view is usually diagnostic (Figure 13).

Non-accidental injury

NAI should be considered in all children presenting to a casualty department with an injury. Of these cases, 80% occur before the age of 2 years. Fractures occur in approximately 50% and are typically multiple, in varying stages of healing (some with periosteal reaction and others with mature callus) and explained by an implausible history. Subperiosteal new bone formation may be caused by subperiosteal bleeding as a result of shaking or squeezing and will become radiographically apparent weeks after the injury (Figure 14).

Figure 13. Left slipped capital femoral epiphysis (SCFE). There is posterior slip of the left capital femoral epiphysis. A straight line drawn along the lateral margin of the femoral neck should normally transect the superior aspect of the femoral epiphysis. a. On the anteroposterior view the left femoral epiphysis is not transected by this line. b. The frog-leg view clearly shows the slip of the left capital femoral epiphysis.

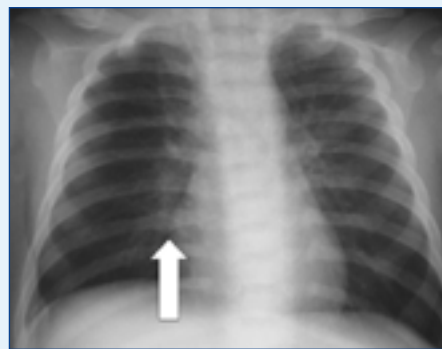


Figure 14. This 18-month-old was brought to casualty with a cough. The bilateral clavicular and posterior right eighth rib fractures (arrow) were noted. Further investigation confirmed non-accidental injury.

Shaft fractures are more common than metaphyseal fractures but the latter are virtually pathognomonic. The corner fracture (or bucket handle) of a metaphysis is caused by tractional or torsional stresses on the limbs and occurs in the long bones. Rib fractures, especially posterior ones, in a child under 2 years are virtually pathognomonic of NAI (Figures 14 and 15). They result from violent shaking episodes and are a recognized association with brain injury and therefore are an indication for a computed tomography scan of the brain.

Other fractures which have a high specificity for abuse include fractures of the scapula, small bones of the hands and feet, pelvis, sternum, vertebral compression and transverse processes. Skull fractures, especially depressed occipital fractures, are highly suggestive. If NAI is suspected senior paediatric advice should be sought. **BJHM**

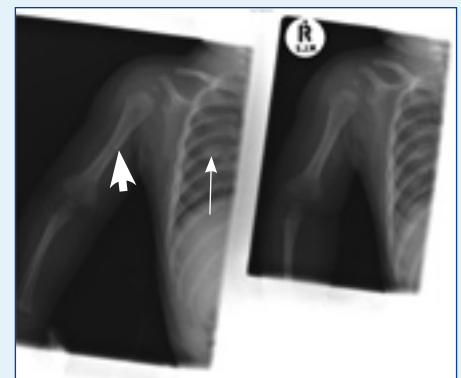


Figure 15. A proven case of non-accidental injury with a right posterior sixth rib fracture (thin arrow) and a fracture of the mid shaft of the humerus with associated periosteal reaction (thick arrow).

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Conflict of interest: none.

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KEY POINTS

- The immature skeleton is more elastic than the adult skeleton resulting in incomplete fractures such as torus, greenstick and plastic bowing injuries.
- Know the Salter–Harris classification of epiphyseal injuries. The type of injury is of prognostic value.
- Supracondylar fractures are the most common fracture in children.
- In suspected slipped capital femoral epiphysis a frog-leg view should always be performed if the frontal view is normal.
- Non-accidental injury (NAI) occurs before the age of 2 years. Characteristic bone injuries of NAI include multiple injuries, in varying stages of healing and explained by an implausible history, posterior rib fractures, metaphyseal corner and depressed occipital fractures.