Principles of paediatric injuries

Introduction

Paediatric injuries differ from those in adults in many respects. This article discusses why this is the case and outlines the general principles of treating paediatric injuries. It will also look at non-accidental injury (NAI), which should always be considered when reviewing a child with a fracture.

Differences between children's and adults' bones

Skeletal trauma accounts for 10–15% of all childhood injuries, with approximately 15% of these representing physeal injuries. Fractures in children have some unique characteristics and differences from those in adults. While the injured adult has to recover from the trauma itself, children also need to cope with any effects of the trauma on their growth.

The biomechanical characteristics of the growing skeleton are also different. Children's bones are more malleable, allowing a plastic type of 'bowing' injury. This may lead to an incomplete fracture (greenstick), which occurs more often in children.

Bone healing is faster in children and complications affecting bone healing are rarer than in adults because the bone is more biologically active with a thick vascular periosteum. The thicker periosteum is more highly developed than in adults and usually remains intact on the concave side of the fracture. This helps stabilize any reduction, decreases the amount of displacement, and is probably a factor in the lower incidence of open fractures in children than in adults. Stiffness across joints after immobilization is less of a problem in children than in adults.

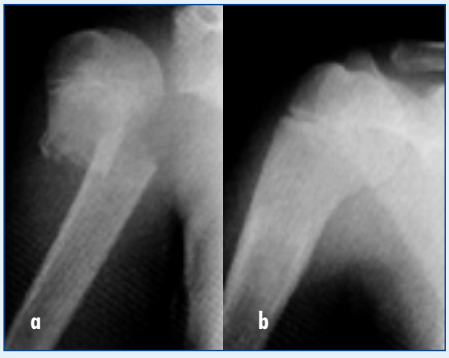
Children's bones remodel to a greater extent than adults' do (*Figure 1*), and therefore a greater amount of angulation and displacement is acceptable in children (apart from intra-articular fractures where angulation or displacement is not acceptable at all). However, rotational deformity does not correct so readily in the young child and should be avoided. Apposition and mild shortening are of little importance in young children. Apposition and remodelling is acceptable in boys under the age of 12 years and girls under 10 years of age. Slight shortening with reduction may be desirable in the leg because acceleration of growth occurs after a displaced fracture.

The long bones of children have epiphyses and physes, the latter of which seem to be the weakest point of the child's skeleton, accounting for the difference between the location of fractures in children and adults. The biomechanical properties change with age and there are characteristic injury patterns for different age groups. Fractures involving the physis only occur in children. The physes should be kept in as near normal condition as possible to avoid growth arrest and angular deformities.

Physeal (growth plate) injuries

These injuries are usually caused by torsion (not tension) at the growth plates. The most common sites for physeal arrest are at the distal femur, distal radius, distal tibia and proximal tibia. Complications of physeal injuries include limb length discrepancies, malunions and physeal arrest. Trauma is the commonest cause of physeal arrest. Computed tomography and magnetic resonance imaging are useful for diagnosing a physeal arrest. Arrest occurs when a bridge of bone (physeal bar) forms between the metaphysis and epiphysis.

Figure 1. a. Fracture of the proximal humerus at 6 years of age. b. The same fracture after conservative treatment aged 10 years. The fracture was not treated operatively as doctors knew it would remodel.



Mr AR Jenabzadeh *is Clinical Research Fellow and* **Mr FS Haddad** *is Clinical Director and Orthopaedic Consultant at University College London Hospitals, London NW1 2BU*

Correspondence to: Mr AR Jenabzadeh

The uninjured portion may continue to grow. Centrally located bars within the physis lead to arrest of longitudinal growth with resultant shortening of the extremity. Peripheral bars (most common pattern) lead to angular deformities. The magnitude of the resultant deformity is determined by the remaining growth of the child as well as the location of the bar.

Salter and Harris came up with a classification system for physeal fractures (*Figure 2*). Type I is a transverse fracture through the physis. Type II is a fracture through the physis with a metaphyseal fragment. Type III is a fracture through the physis and into the epiphysis (intra-articular). Type IV is a fracture through the epiphysis, physis and metaphysis. Type V is a crush injury through the physis. Type I and II have an excellent prognosis, although complete or partial growth arrest may occur in displaced fractures. Type II and III have a worse prognosis, as growth arrest and angular deformity are common problems. Type V fractures have poor prognosis.

Repeated reduction attempts may increase the incidence of growth plate injuries.

General principles of operative fracture treatment in children

Few children's fractures require open reduction and internal fixation. If it is necessary, then certain principles should be followed. Repositioning of fragments should be in an anatomical position, otherwise the resulting offset will cause a bony bridge and joint incongruity. Fixation should be used that can be removed readily. Smooth pins should be used rather than threaded pins and fixation should not cross the physis wherever possible. The placement of compression screws across epiphyseal fragments, parallel to the physis, is an effective means of restoring stable articular congruity. Unnecessary drill holes should be avoided as they may later become iatrogenic fractures. Absorbable sutures should be used to avoid distress to the child on removal of sutures.

Child abuse (non-accidental injury)

A high index of suspicion is needed to make the diagnosis. The highest percentage of child abuse occurs between birth and 2 years of age. Neglect is more common than abuse. Children of all socioeconomic backgrounds suffer physical abuse or neglect; however, the incidence does seem to be related to family income. Children with the highest risk of abuse include first-born, unplanned, premature and stepchildren. Children with an increased risk of abuse include children in a single-parent home, children of parents who abuse drugs, children of parents who were abused, children of unemployed parents, and children of families of lower economic status.

NAI is most common in children under the age of 3 years. Approximately one third of abused children are eventually seen by an orthopaedic surgeon. An unusual or questionable history or the finding of multiple skin bruises or burns should alert the doctor to the possibility of child abuse. Knowledge of the injury patterns suggestive of NAI in children is essential (*Table 1*). The most common locations (but least specific) for fractures in child abuse are the humerus, tibia and femur.

Figure 2. Salter Harris classification of epiphyseal plate injuries I-V.

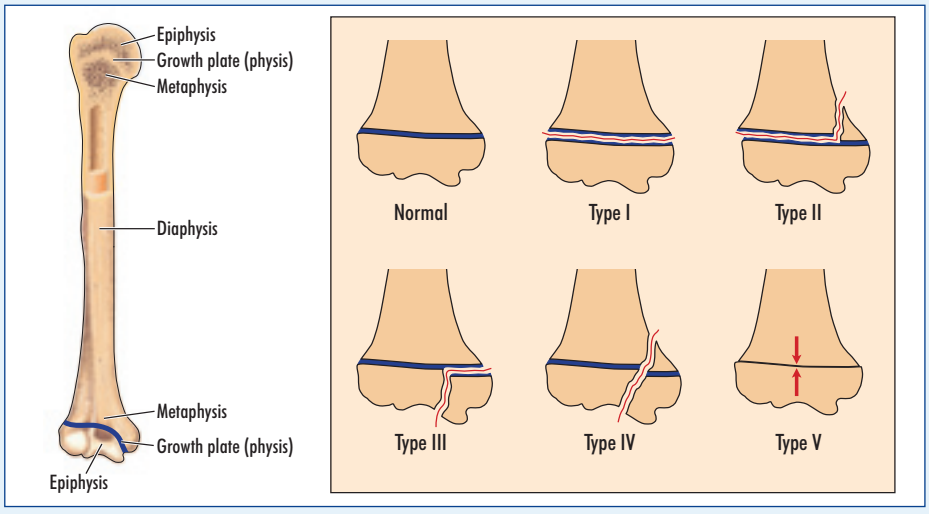


Table 1. Injuries suggestive of child abuse

High specificity	Posterior rib fractures
	Sternal fractures
	Scapular fractures
	Spinous process avulsion fractures
Moderate specificity	Multiple fractures
	Fractures in various stages of healing
	Vertebral compression fractures
	Epiphyseal separations

The differential diagnosis in cases of suspected child abuse include true accidental injury, osteogenesis imperfecta and metabolic disease.

Skeletal survey is a useful initial imaging modality. Nuclear medicine bone scanning may be helpful when the skeletal survey is negative. BJHM

Conflict of interest: none.

Further reading

Beaty JH (1997) Orthopaedic aspects of child abuse. *Curr Opin Pediatr* **9:** 100–3

Currey J, Butler G (1975) The mechanical properties of bone tissue in children. *J Bone Joint Surg* **57A:** 810–14

Landin LA (1983) Fracture patterns in children. *Acta Orthop Scand* **54**(Suppl 202): 1–109

KEY POINTS

- Children's bones are more malleable and more biologically active with a thick vascular periosteum.
- Children's bones remodel to a greater extent than adults' do, so a greater amount of angulation and displacement is acceptable in children.
- Rotational deformities do not remodel acceptably and should be avoided.
- The closer the fracture is to the joint (physes), the better the deformity is tolerated.
- As a general rule, the younger the patient, the greater the potential for remodelling.
- The physes are weak links in the growing skeleton and account for the difference between the location of fractures in children and adults.
- Complications of physeal injuries include limb length discrepancies, angular deformities, malunions and physeal arrest.
- A high index of suspicion is needed to diagnose non-accidental injury.