Children's forearm fractures

Michael Mokawem

Brian Scott

Abstract

Forearm fractures in children are commonly encountered by orthopaedic surgeons, who are expected to manage these fractures with a thorough understanding of the nature of fracture, the acceptable displacement which will remodel and the appropriate treatment modalities available should intervention be indicated. The incidence of these fractures remains high, as children are prone to participation in high-risk activities on a regular basis. Activities such as trampolining, ice skating, cycling and the use of climbing frames will ensure that these fractures continue to present in large numbers. Treatment modalities are well established but not universally well followed. Distal fractures are most commonly amenable to closed treatment methods. In contrast, there should be a low threshold for surgical stabilization in shaft fractures. Flexible intramedullary nailing has contributed significantly to the better management of shaft fractures, which can be very difficult to treat successfully with other methods. An increased awareness of those fractures that have a high risk of displacement following reduction will lead to better selection of fractures likely to benefit from early surgical stabilization. Overall, excellent outcomes can be expected if care is taken to treat these fractures appropriately.

Keywords forearm fractures; flexible nailing; growth plate; Monteggia; redisplacement

Introduction

Children's forearm fractures present a challenge to trauma and orthopaedic surgeons throughout their career. These fractures make up a significant portion of the work in both major trauma centres and smaller units. Correct management of these injuries relies upon a sound understanding of the specific injury, as well as an ability to accurately predict the remaining growth and remodelling potential of the developing skeleton. Trauma and orthopaedic surgeons need to be proficient in closed reduction and casting techniques, which lay a strong foundation for the competent management of these fractures. Vitally, they need to be skilled in the art of open reduction and surgical stabilization to confidently intervene surgically when the correct indications are present. Furthermore, being adept at the outpatient management of these fractures requires an ability to accurately assess the fracture as well as effectively communicate with the child and the parents, often reassuring parents regarding remodelling potential, stiffness and the risk of refracture.

Michael Mokawem *MB ChB MRCS Specialty Registrar in Trauma and Orthopaedic Surgery, Leeds General Infirmary, Leeds, West Yorkshire, UK. Conflicts of interest: none declared.*

Brian Scott *MB BS FRCS (Orth) Consultant Trauma and Orthopaedic Surgeon, Department of Trauma and Orthopaedics, Leeds General Infirmary, Leeds, West Yorkshire, UK. Conflicts of interest: none declared.*

This article will encompass forearm fractures in children distal to the elbow region as well as Monteggia fractures, which are forearm fractures with associated elbow involvement. Primary injuries of the elbow region in children are outside the scope of this article.

Principles of management

Epidemiology

Numerous epidemiological studies have shown the incidence of fractures in the paediatric population to be in the region of 20/1000/year. This is almost twice the incidence seen in adults and it is thought to be increasing due to increased participation in high risk sporting activities as well as increased levels of obesity. It is estimated that nearly one third of all children will, at some time, experience a fracture. Forearm fractures account for about 40 percent of all paediatric fractures and distal radius fractures make up three quarters or more of these. There is a predominance in males seen in both distal (55%) and shaft (66%) fractures. Distal radius fracture incidence shows a unimodal pattern with a steady increase in both sexes through early childhood, peaking at the age of 12–14 and then decreasing. The incidence of shaft fractures differs between boys and girls. Girls have a unimodal distribution peaking at around 6 years of age but boys have a bimodal distribution with a peak at around 6–7 and then a large spike in the teenage years, highest at 14 years of age.[1]

Children's bone

Enchondral ossification at the physis leads to bone lengthening, while peripheral growth at the physis takes place in the zone of Ranvier. Peripheral growth along the diaphysis is due to deposition of bone beneath the periosteum, referred to as appositional ossification.[2] Compared with adults, the periosteum in a child is an enormously strong, thick structure. Even in complete fractures, the periosteum is often intact. This allows most paediatric fractures to be treated non-operatively, as it will aid reduction and then assist in controlling the reduction. When the periosteum is disrupted, fractures are much more difficult to reduce and a low threshold for surgical stabilization should exist.

Paediatric bone is less dense than adult bone due to a lower mineral content. It has a lower bending strength but also a lower modulus of elasticity which allows it to absorb more energy before it fractures.[3] Three unique incomplete fracture patterns are seen in paediatric bones:

- Buckle or Torus fractures
  Metaphyseal fractures. The bone fails in compression.
- Plastic deformation
  Angulation exceeds the elastic limit, leading to microscopic failure of the tension side which does not propagate to the compression side.
- Greenstick fractures
  A continuum of plastic deformation in which an increased bending force causes the tension side to fracture but the fracture does not propagate to the compression side.[3]

Physeal micro-anatomy

A well organised process of chondrocyte maturation takes place at the physis through four layers arranged perpendicular to the long axis of the bone (Figure 1). As the chondrocytes mature through the

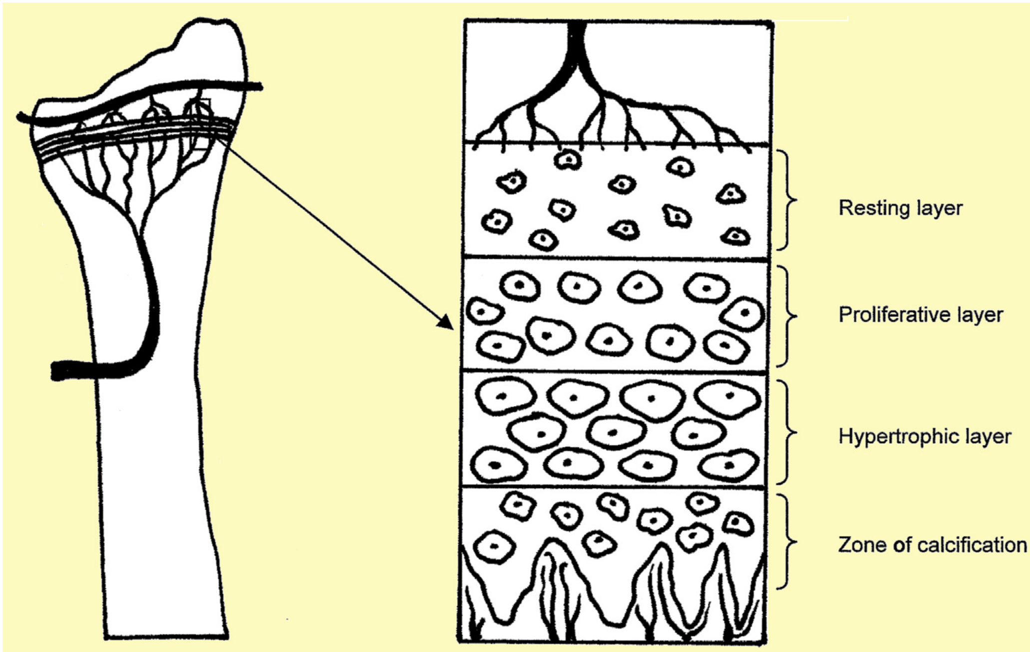

Figure 1 Physeal microanatomy with growth plate layers.

layers, they progressively hypertrophy, resulting in less space for the strong surrounding extracellular matrix. This is most evident in the hypertrophic layer where the physis is most susceptible to fractures. In the final layer (Zone of calcification) metaphyseal vascularization leads to programmed cell death of chondrocytes, calcification of the extracellular matrix and formation of osteoblasts and osteoclasts which produce primary bone and are involved in remodelling. The ring of La Croix is a strong, fibrous structure which stabilizes the epiphysis on the metaphysis.[2]

Remodelling potential

Although there is great scope for remodelling in the plane of joint movement, rotation will not remodel. Angulation will remodel more in distal fractures due to approximately 75% of radial growth taking place at the distal physis.[4] The following is a guide as to how much angulation can be expected to remodel satisfactorily.[5]

- Distal
  - Under 10 years of age: up to 30 degrees
  - Over 10 years of age: up to 15 degrees
- Shaft
  - Under 6 years of age: up to 15 degrees
  - 6–12 years of age: up to 10 degrees
  - Over 12 years of age: minimal

These figures are supported in the literature: Armstrong et al.[6] and Price et al.[7] have shown that distal fractures remodel in the sagittal plane at +- 0.9 degrees per month and in the frontal plane at +- 0.8 degrees per month. Only minimal remodelling takes place after the age of 12 years and only very limited remodelling of angular deformities in the frontal plane will take place after the age of 9 years.[8]

Mechanism of injury

Falls from a height of less than 1 m (+-50%) are responsible for nearly twice as many fractures as fall from a height of more than 1 m (+-25%).[1] Sports (football and gymnastics) related injuries and falls from bicycles are commonly seen. Trampolines and monkey bars are frequently implicated, while activities such as ice skating and skiing also contribute significantly to the genesis of these fractures.[9]

Presentation

The mechanism of injury often dictates the presentation and any patient who presents following a high energy mechanism should be managed according to Advanced Trauma Life Support principles. Children usually present with pain shortly after the incident, although with less severe injuries such as torus fractures the presentation may be delayed, as the symptoms will be mild. An obvious deformity may be present and the child or accompanying adult may be cradling or supporting the limb. It is important to give the child appropriate analgesia as soon as possible once it has been established that there are no contraindications such as head injury or allergy. This settles the child to allow a full history, examination, imaging and initial splinting. As soon as the child has settled sufficiently to allow examination, this should take place along the established formula of 'look, feel and move'. Be sure to get a circumferential view of the arm so as not to miss a wound or open fracture. The examination should include the whole of the ipsilateral limb because simultaneous injuries may occur. No more than gentle palpation should be attempted at the site of injury. The entire forearm should be carefully examined to include the wrist and elbow joints, as well as the distal radio-ulna joint. A careful neurovascular examination is then carried out to specifically establish whether this is intact. A radial pulse is identified and capillary refill time is tested: the findings are documented. Sensation is tested by light touch over the ulna side of the little finger (ulna nerve), palmar side of the index finger and thumb (median nerve) and dorsum of first web space (radial nerve). Motor function is tested by asking the patient to give a "thumbs up" (extensor pollicis longus

