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Review article

Proximal humerus fractures in children and adolescents

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ABSTRACT

Proximal humerus fractures are rare in paediatric traumatology. Metaphyseal fractures account for about 70% of cases and epiphyseal separation for the remaining 30%. The development and anatomy of the proximal humerus explain the various fracture types, displacements, and potential complications; and also help in interpreting the radiographic findings, most notably in young children. Physicians should be alert to the possibility of an underlying lesion or pathological fracture requiring appropriate diagnostic investigations, and they should consider child abuse in very young paediatric patients. Although the management of proximal humerus fractures remains controversial, the extraordinary remodelling potential of the proximal humerus in skeletally immature patients often allows non-operative treatment without prior reduction. When the displacement exceeds the remodelling potential suggested by the extent of impaction, angulation, and patient age, retrograde elastic stable intramedullary nailing (ESIN) provides effective stabilisation. As a result, the thoraco-brachial abduction cast is less often used, although this method remains a valid option. Retrograde ESIN must be performed by a surgeon who is thoroughly conversant with the fundamental underlying principles. Direct percutaneous pinning is a fall-back option when the surgeon's experience with ESIN is insufficient. Finally, open reduction is very rarely required and should be reserved for severely displaced fractures after failure of closed reduction. When these indications are followed, long-term outcomes are usually excellent, with prompt resumption of previous activities and a low rate of residual abnormalities.

Proximal humerus fractures (PHF) are uncommon but characteristic post-traumatic lesions in children and adolescents. The anatomic characteristics of the proximal humerus largely explain the various fracture presentations, complications, and outcomes.

The management of PHF underwent a major change in 1985 with the introduction of retrograde elastic stable intramedullary nailing (ESIN). ESIN has steadily gained ground over non-operative management, although the best criteria for choosing between these two treatment options are still not agreed on.

1. The proximal humerus

1.1. Development and growth of the proximal humerus

The proximal humeral physis is composed of three ossification centres, for the head, lesser tuberosity, and greater tuberosity, respectively. The capital centre appears at 3 months of age at the latest, whereas the two other centres appear at 1 year of age and fuse between 3 and 5 years of age to produce the tuberosity ossification centre. Finally, at about 6 years of age, the capital and tuberosity centres fuse into a single proximal epiphyseal centre. At this point, the proximal humerus physis acquires a characteristic tent shape (Fig. 1a) responsible for a radiographic double contour that complicates the interpretation of the images [1].

The proximal humerus physis accounts for nearly 80% of the longitudinal growth of the humerus, a fact that translates into an extraordinary potential for remodelling (Fig. 2).

The last growth plates to close are those of the long bones (16–17 years in girls and 18 years in boys) [2]. Consequently, epiphyseal separation can occur in adolescents, who can experience remodelling in the event of malunion.

1.2. Specific anatomic characteristics of the proximal humerus

The joint capsule insertion follows the lateral edge of the physis then dips downwards vertically on the medial aspect of the metaphysis (Fig. 1b). This configuration explains the high proportion of Salter-Harris type II epiphyseal separations with a fracture line that follows the joint capsule insertion, detaching a medial wedge of the metaphysis together with the epiphyseal fragment [3].

The muscle attachments to the proximal humerus contribute to explain the displacement of the fragments. The rotator cuff attaches proximal to the pectoralis major and deltoid muscles.

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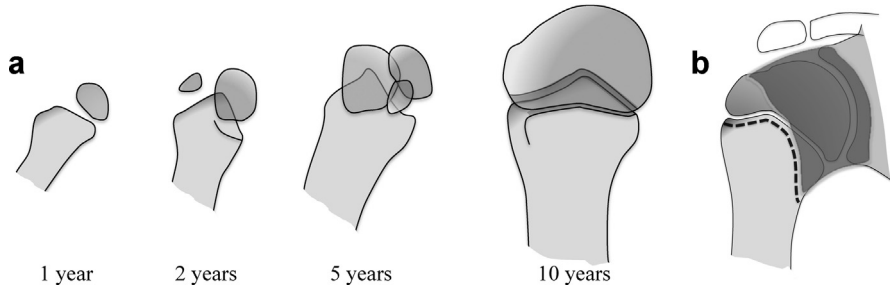

Fig. 1. Development and anatomy of the proximal humerus: a: appearance of the proximal humeral epiphysis during growth, with the development of secondary ossification centres (head at 1 year of age, lesser tuberosity around 2 years of age, and greater tuberosity around 5 years of age), which fuse before 10 years of age. The apparently eccentric position of the ossification centres within the epiphysis explains that the normal appearance can be mistaken for epiphyseal separation; b: configuration of the gleno-humeral joint capsule attachment to the proximal humerus, which explains the frequency of epiphyseal separation with detachment of a medial metaphyseal wedge.

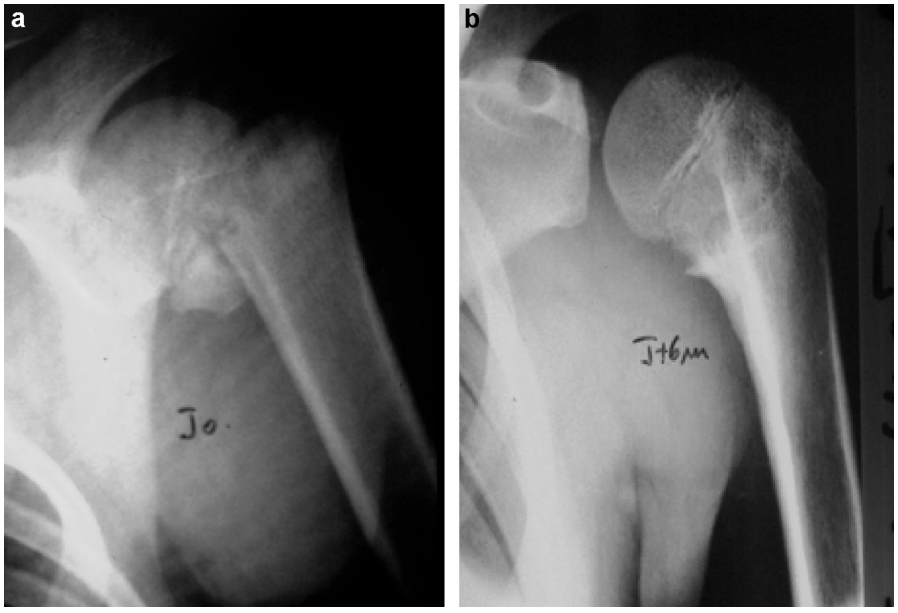

Fig. 2. Example of remodelling of a proximal humerus fracture in a skeletally immature 10-year-old boy: a: on day 0; b: 6 months after non-operative treatment consisting in immobilisation for 6 weeks without reduction.
Courtesy of P. Journeau.

Another important factor is the proximity of soft-tissue structures, including the long head of biceps tendon, which runs through the gleno-humeral joint cavity. In addition, the axillary artery and nerve trunks emerging from the brachial plexus travel medial to the humeral head. These structures should be considered when analysing PHFs and planning the treatment strategy for the fracture and potential complications.

2. Proximal humerus fractures (PHFs)

2.1. Epidemiology

The incidence distribution of PHFs over the life span shows an early modest peak between 10 and 14 years of age followed by a return to low levels in young adults then by an increase after 45 years to a maximum after 70 years [4].

In neonates, PHFs account for one-third of all humerus fractures, which are exceedingly rare (0.03/1000 births) [5]. In children and adolescents, PHFs contribute only 0.5% to 3.5% of all fractures [4,6].

In the youngest age groups, abuse can result in PHFs (by order of frequency, the sites of humerus fractures due to abuse are the diaphysis, distal humerus, and proximal humerus.) In patients younger than 18 months of age, two-thirds of all humerus fractures may be related to abuse [7].

Finally, the proportion of metaphyseal fractures is higher in pre-pubertal patients, whereas the proportion of epiphyseal separations is higher in adolescents.

2.2. Causes and mechanisms

In neonates, traction on the upper limb during a difficult vaginal or caesarean extraction can result in a PHF [5,8]. In young paediatric patients, particularly those who are victims of abuse, PHFs result from repeated brutal traction on the abducted upper limb. Among older children and adolescents, boys are affected in 60% of cases, and PHFs chiefly involve the non-dominant arm.

For all PHF types, the usual cause is a backwards fall on the arm with the upper limb adducted, the elbow extended, and the shoulder extended and rotated externally. In adults, this mechanism usually results in antero-medial dislocation of the gleno-humeral joint. A direct fall on the tip of the shoulder is less common, and torsion forces are the least frequent mechanism.

The falls that cause these mechanisms occur in a variety of circumstances. About one-fourth of the falls are related to sports and another third to motor vehicle accidents. Furthermore, one-fourth of patients have a lesion at another site (fracture of another long bone, injury to an internal organ, or neurosurgical injury).