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Elbow Fractures in Children and Adolescents

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Abstract

Fractures of the upper extremity are common injuries in athletically active children and adolescents. These injuries usually occur during falls on an outstretched arm. Upper extremity fractures account for 65% to 75% of fractures in this group, and fractures about the elbow for approximately 10%. Although most elbow fractures heal uneventfully with immobilization only, determining which fractures will do well with cast treatment alone and which require surgical reduction and stabilization is often difficult.

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An accurate diagnosis is imperative in avoiding risks associated with the treatment of elbow fractures in children. The normal ossification centers of the elbow must be distinguished from abnormal processes. Knowledge about the sequence and timing of ossification of these centers[1] is essential (Table 1) (Fig. 1). Other anatomic landmarks that can aid in diagnosis are the olecranon (posterior), coronoid (anterior), and supinator fat pads that overlie the major structures of the elbow. Displacement of any of the fat pads is indicative of the presence of an occult fracture, but displacement of the posterior fat pad is considered the most reliable sign. Skaggs and Mirzayan[2] reported that 34 of 45 children (76%) with a history of elbow trauma and an elevated posterior fat pad had radiographic evidence of elbow fractures at an average of 3 weeks after injury, even though AP, lateral, and oblique radiographs taken at the time of injury showed no other evidence of fracture. Donnelly and associates,[3] however, found evidence of fracture in only 9 of 54 children (17%) who had a history of trauma and elbow joint effusion but no identifiable fracture on initial radiographs.

A line drawn along the anterior border of the distal humeral shaft should pass through the middle third of the ossification center of the capitellum (Fig. 2); if this anterior humeral line passes through the anterior portion of the lateral condylar ossification center or anterior to it, posterior angulation of the distal humerus is present.[4]

Routine radiographic examination should include AP, lateral, and oblique views. An arthrogram may be helpful to determine the extent of displacement with lateral or medial condylar fractures, and in selected patients MRI or ultrasonography also may aid in evaluation of injury to an unossified epiphysis.

Table 1
Timing of Normal Ossification[1]

Ossification Center	Girls (Years of Age)	Boys (Years of Age)
Capitellum	1.0	1.0
Radial head	5.0	6.0
Medial epicondyle	5.0	7.5
Olecranon	8.7	10.5
Trochlea	9.0	10.7
Lateral epicondyle	10.0	12.0

Supracondylar Fractures

Supracondylar humeral fractures are the most common elbow fractures, accounting for 70% of all elbow fractures in children, and they also are the source of much physician distress.[5] Treatment recommendations generally are based on the classification of the fracture: type I, nondisplaced; type II, displaced but with cortical contact; and type III, completely displaced.[6] Type I fractures generally can be

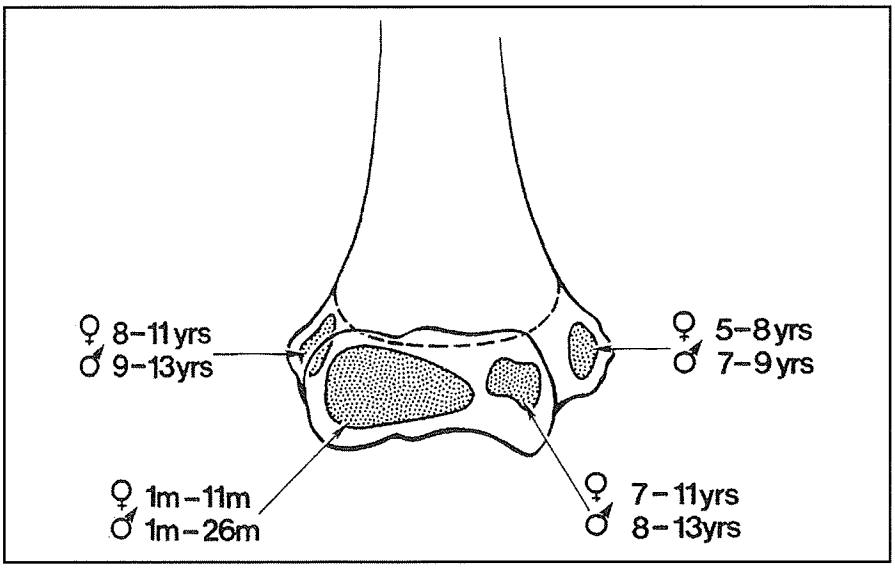

Fig. 1 The appearance and fusion of the four secondary ossification centers of the elbow are shown. The ages at which fusion of the secondary ossification centers occurs is also noted. (Reproduced with permission from Beaty JH, Chambers HG, Toniolo RM: Fractures and dislocations of the elbow region, in Rockwood CA Jr, Wilkins KE, Beaty JH (eds): *Fractures in Children*, ed 4. Philadelphia, PA, Lippincott-Raven, 1996, p 661.)

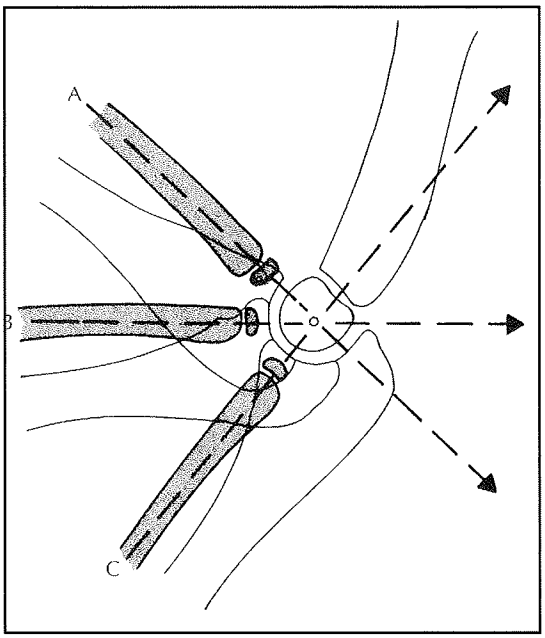

Fig. 2 A line drawn along the anterior border of the distal humeral shaft should pass through the middle third of the ossification center of the capitellum. (Reproduced with permission from Smith FM: Children's elbow injuries: Fractures and dislocations. *Clin Orthop* 1967;50: 7-30.)

treated with 3 weeks of immobilization in a posterior splint or long arm cast, type II fractures may require reduction and percutaneous pinning for severe varus or valgus impaction, and type III fractures generally are best treated by closed reduction and percutaneous pinning to avoid vascular and neurologic complications and angular deformities (cubitus varus). Type II fractures with medial impaction are especially prone to the development of cubitus varus; reduction and pinning are imperative to prevent this complication. Open reduction occasionally is required for irreducible fractures, open fractures, or fractures accompanied by vascular injury. The current trend is toward anterolateral open reduction of posteromedially displaced fractures.

About 10% of patients with type III supracondylar fractures present with a pulseless but pink and viable hand;[7-9] arteriogram is not indicated as part of the preoperative evaluation, and few of these patients require surgical treatment for brachial artery injury.[9] After immediate closed reduction and stabilization with Kirschner wires and avoidance of extreme flexion of the elbow, pulse generally returns within days. Obliteration of the radial pulse after closed reduction and pinning is a strong indication for brachial artery exploration, as is persistent vascular insufficiency after reduction and pinning.

Nerve injuries occur with approximately 7% of supracondylar fractures. Reports differ as to whether the radial or medial nerve is the most frequently injured; in most modern series, the anterior interosseous nerve appears to be the most commonly injured, with loss of motor power to the flexor pollicis longus and the deep flexor to the index finger.[8,10,11] Observation generally is all that is necessary; rarely, exploration might be considered for nerve dysfunction that persists more than 6 to 12 months.

Flexion-type supracondylar fractures account for approximately 2% of humeral fractures.[5] Type III flexion fractures can be difficult to reduce closed and, because reduction is obtained with the elbow in extension, pinning of the distal fragment can be quite difficult. Pinning usually is done with the elbow in about 30° of flexion. Open reduction frequently is required and is best accomplished through a posterior approach.

Lateral Condylar Fractures

Lateral condylar fractures are classified according to the amount of displacement:

type I, 2 mm or less; type II, 2 to 4 mm; and type III, completely displaced and rotated.[12] Type I and most stable type II fractures can be splinted but should be checked weekly until union is achieved. The risk of late displacement is 5% to 10% and often depends more on the degree of associated soft-tissue injury and whether the articular cartilage of the trochlea is intact than on the amount of initial displacement.[13] Percutaneous pinning can ensure maintenance of reduction in questionable type I and II fractures with 2 to 4 mm of displacement. Unstable type II and III fractures generally require reduction and internal fixation (about 60% of fractures involving the lateral condylar physis). If there is any question as to the stability of the reduction, open reduction and internal fixation with smooth Kirschner wires should be done. Extreme care must be taken to avoid dissection near the posterior portion of the fragment because this is the entrance of the blood vessel supplying the lateral condylar epiphysis. The wires are buried under the skin and motion is begun early (2 weeks); wires are removed at 3 to 4 weeks after injury.[14]

Nonunion of lateral humeral condylar fractures can result in cubitus valgus deformity and tardy ulnar nerve palsy. Surgical treatment generally is appropriate for nonunions in optimal position: large metaphyseal fragment, displacement of less than 1 cm from the joint, and a normal lateral condylar physis. A modified open reduction, screw fixation, and a lateral extra-articular iliac crest bone graft are recommended.

Medial Epicondylar Fractures

Fractures of the medial epicondyle can be caused by a direct blow or by avulsion and extension mechanisms (valgus stress) sustained in a fall on the outstretched arm. Chronic tension stress injuries can occur (little leaguer's elbow), and isolated avulsion can occur in adolescents while pitching a baseball. Many of these injuries are associated with an elbow dislocation that may or may not have reduced spontaneously.[15]

Fracture of the medial epicondyle may be mistaken for fracture of the medial condylar physis, especially if the secondary ossification centers are not present. Widening or irregularity of the apophyseal line may be the only clue in fractures that are only slightly displaced or nondisplaced. If the fragment is significantly displaced, the diagnosis usually is obvious on radiographs; however, if the fragment is totally incarcerated in the joint, it may be hidden by the overlying ulna or distal humerus. The clue here is the total absence of the epicondyle from its normal position just medial to the medial metaphysis. Even displaced fractures of the medial epicondyle may not produce positive fat pad signs, so a high index of suspicion is necessary to ensure that a fracture does not remain unrecognized. Arthrography or MRI can be helpful in evaluating medial condylar fractures in young children.

Nonsurgical treatment generally is recommended for nondisplaced and minimally displaced fractures and even significantly displaced (1 cm) fractures in patients with low upper extremity functional demands.[16] An absolute indication for surgical treatment is a fracture that cannot be reduced because of an incarcerated fragment in the joint. Open reduction also may be indicated for fractures with more than 1 cm of displacement, ulnar nerve dysfunction, and patients with high upper extremity functional demands, such as baseball pitchers, tennis players, football quarterbacks, wrestlers, and gymnasts. Fixation must be stable enough to allow early motion, and most patients with these fractures are mature enough so that the fragment can be secured with a threaded or cannulated screw. Because stiffness is the most common complication of this injury, especially with a concomitant elbow dislocation, early active motion should be encouraged.

Capitellar Fractures

Fractures of the capitellum are rare in children and have most often been reported in adolescent athletes.[17] This fracture often is difficult to diagnose because there is little ossified tissue. It is composed mainly of articular cartilage from the capitellum and essentially nonossified cartilage from the secondary ossification center of the lateral condyle. In young children, arthrography or MRI may be necessary for diagnosis. Treatment of this injury is either excision or open reduction and reattachment of the fragment. If the fragment is large (1 cm or larger), acute, and an anatomic reduction can be obtained with a minimum of open dissection or manipulation, it should be reattached with two small compression or Herbert screws inserted from posterior to anterior through a lateral approach. If it is an old fracture, if any comminution of the fragment is present, or if there is little bone in which to engage the screw threads, excision of the fragment and early motion probably are more appropriate.

Radial Head and Neck Fractures

Fractures of the radial head and neck are relatively infrequent, accounting for only 5% of all elbow fractures; most are sustained in falls.[18] Treatment should be nonsurgical if possible, but varying amounts of angulation and displacement can be accepted. Most agree that percutaneous manipulation or open reduction and fixation are required if angulation is more than 45° and displacement more than 50%.[18] Closed reduction can be attempted by applying a varus stress to the pronated forearm (Patterson technique). A unique opportunity to reduce radial neck fractures by application of a tourniquet alone has also been described. If unsuccessful, percutaneous pin reduction with the use of fluoroscopy or intramedullary pin reduction can be attempted. Fixation with oblique Kirschner wires is preferred if open reduction is required; transcapitellar wires should be avoided if possible.

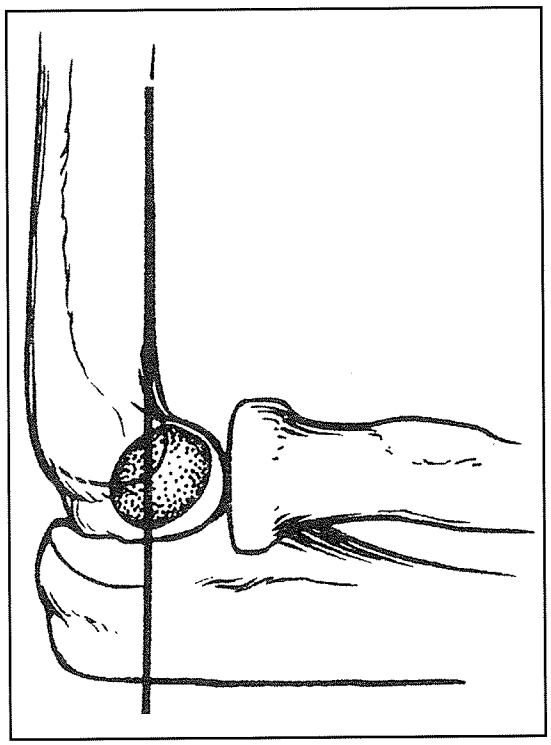

Fig. 3 A straight line drawn through the radial head should pass through the center of the capitellum, regardless of the degree of flexion or extension of the elbow. (Reproduced with permission from Beaty JH, Chambers HG, Toniolo RM: Fractures and dislocations of the elbow region, in Rockwood CA Jr, Wilkins KE, Beaty JH (eds): *Fractures in Children*, ed 4. Philadelphia, PA, Lippincott-Raven, 1996, p 661.)

These fractures may be difficult to see on radiographs before ossification is complete, and variants in the ossification process can resemble a fracture. Radiographs should be carefully scrutinized because late treatment of these injuries is difficult and often unsuccessful.

Monteggia Fracture-Dislocations

Monteggia fracture-dislocations involve dislocations of the radial head associated with fractures of the ulna and are most often classified according to the direction of the dislocation of the radial head: type I, anterior; type II, posterior; type III, lateral; and type IV, anterior with radial shaft fracture below the level of the ulnar fracture.[19] Types I and III (anterior and lateral dislocations) are most common.[20] Most of these fractures can be treated with closed reduction of the ulnar fracture and the dislocated radial head and cast immobilization in a stable position for 6 weeks. Concentric reduction can be confirmed by drawing a straight line through the radial head; in any position, this line should pass through the center of the capitellum[21] (Fig. 3).

Open reduction is required for soft-tissue interposition that makes radial head reduction impossible; an unstable ulnar fracture (not out to length and straight) may require fixation with a plate and screw device or an intramedullary rod. Intramedullary rod fixation is becoming a more popular option as more experience is gained with this technique. Transcapitellar pinning should be avoided. The pitfall with this injury is the variety of Monteggia-equivalent variants.

If the Monteggia fracture-dislocation is discovered late, options for treatment are observation, excision of the radial head at skeletal maturity, and late reconstruction with ulnar lengthening angulation osteotomy and annular ligament reconstruction. This is a challenging procedure and experience is required.

Summary

Most fractures about the elbow in children can be treated with immobilization only, but some require surgical reduction and fixation to prevent complications such as nonunion and malunion. Closed reduction and percutaneous pinning can provide adequate fixation for many elbow fractures in children and adolescents. Open reduction generally is required for irreducible fractures, open fractures, or fractures accompanied by neurovascular injury. Careful physical and radiographic evaluation will help determine the appropriate treatment for each fracture.

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