Common Elbow Fractures in Children

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Approximately 75 percent of all fractures sustained by children occur in the upper extremities and frequently occur during a fall onto an outstretched hand. The majority of these injuries involve the wrist and forearm, but the elbow alone accounts for approximately 10 percent of all fractures in children. Elbow fractures in children are challenging because of the abundance of unossified cartilage and the high potential for limb-threatening damage to neurovascular structures. Common types of elbow fractures include supracondylar, lateral condylar, medial epicondylar, radial neck and transphyseal fractures.

Understanding elbow fractures in children begins with a basic knowledge of normal elbow anatomy (Figure 1) and how anatomy correlates with what is seen (or not seen) on radiographs (Figures 2a and 2b). The elbow is primarily a hinge joint, with the distal humerus articulating with the ulna and radius. The ulna articulates with the trochlea, whereas the radial head articulates with the capitellum. Strong muscular and ligamentous attachments at the medial and lateral humeral condyles play a vital role in fracture patterns and deformity.

At birth, essentially the entire elbow...
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Radiographic Basics

Fractures in children often occur through unossified cartilage, making radiographic interpretation confusing. Frequently, a small rim of bone can be seen and appears as an innocent “avulsion fragment.” However, these fracture fragments are frequently larger than they appear radiographically.

The capitellar ossification center is usually present by one year of age and can be used to establish basic landmarks in most injured elbows. Figures 4a and 4b demonstrate the relationship of the capitellum to the radius and the humeral shaft. The radius points to the capitellum in all views. A line drawn down the anterior surface of the humerus should always bisect the capitellum on the lateral view. The capitellum on the distal humerus is angled approximately 40 degrees anterior to the axis of the humeral shaft. In the anteroposterior view, the ulna and radius are centered beneath the humeral shaft and are angled slightly laterally in the so-called carrying angle of approximately 15 degrees.1,2

If any of these relationships appear questionable on radiographs, a comparison view of the normal elbow should be obtained. If no abnormalities are seen in an obviously injured elbow, internal and external oblique radiographs should be obtained in addition to the routine anteroposterior and lateral views.

Clinical Evaluation

Common pitfalls that may occur in the treatment of elbow injuries in children are...

FIGURE 4A. Lateral radiograph showing normal relationships of the elbow in a child between one and three years of age. Note the constant relationship of the capitellar epiphysis to the radial and humeral shafts. The capitellar epiphysis lies approximately 40 degrees anterior to the humeral shaft axis on the lateral view. The anterior humeral line should always bisect the capitellar epiphysis on the lateral view.
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FIGURE 4B. Anteroposterior radiograph showing normal relationships of the elbow in a child between one and three years of age. The radial shaft axis should always point to the capitellar epiphysis on anteroposterior and lateral radiographs. There is an approximately 15 degree carrying angle between the humeral and radial shaft axis lines.

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listed in Table 1. Initial evaluation begins with a thorough neurovascular examination. This is paramount, because elbow fractures can often damage the brachial artery or any of the three major nerves (median, ulnar and radial) supplying the hand.

While a neurovascular examination is often difficult in a crying and frightened child, it must be done—preferably before the child is sent for radiographs. A cool, pulseless extremity signals an emergency. Brachial and radial pulses, capillary refill and hand temperature should be checked. If the pulse is equivocal, a Doppler scan should be done. An evaluation of nerve function can be challenging in an uncooperative patient. Does the child withdraw to stimuli of the “autogenous sensory zones” for the median, ulnar and radial
nerve (the tip of the index finger, the tip of the small finger and the dorsal thumb web space, respectively)? This withdrawal maneuver can usually be used to document the child's ability to flex and extend the fingers and wrist. Can the child raise the thumb or wrist (radial motor nerve)? Will he or she flex the thumb or index finger (median motor nerve)? The motor status of the ulnar nerve is the most difficult to assess in an uncooperative patient, but flexion of the tip of the fifth finger is usually the easiest method. Medial and lateral movement of the index finger (Egawa's sign), when obtainable, is the most sensitive indicator of ulnar nerve function. In a cooperative patient, the fastest way to evaluate all three motor nerves is to have the patient flex the fingers with the metacarpophalangeal joints actively extended and then appose the thumb to the little finger.

As part of the physical examination, other associated injuries should be considered. The joints above and below the site of obvious injury should also be examined. During a fall, the entire extremity is subjected to the same load, and, especially in the presence of supracondylar fractures, an associated wrist, forearm or shoulder fracture is not uncommon. Open fractures and/or neurovascular injuries require urgent orthopedic surgical intervention and should be approached as true emergencies.

COMPARTMENT SYNDROME

Increasing pain in the forearm and decreasing sensation in the hand are cardinal signs that a compartment syndrome is beginning. Compartment syndrome with vascular compromise is more common in supracondylar fractures than in other types of fractures, but it can occur in any elbow or forearm fracture. The pain of compartment syndrome is exacerbated by stretching the muscles that are becoming ischemic, usually the volar forearm compartments. If passive extension of the fingers causes severe pain, a volar compartment syndrome is likely. Volkman's ischemic contracture is the preventable end result of untreated forearm compartment syndrome and is not salvageable once the muscles have become necrotic. The patient is left with a nearly useless hand.

SPLINTING THE ELBOW

Splinting the injured elbow should be the first step once the physical and neurovascular examination are completed and before the patient undergoes radiographic evaluation. To prevent further damage to vital structures by sharp, fractured bony ends, "splint them where they lie" is the safest course of action with most fractures. However, to place the least amount of tension on nearby neurovascular structures, it is best to splint supracondylar fractures with the elbow flexed 20 to 30 degrees. This is especially important if the arm is pulseless and in the extended position. Merely flexing the elbow to 20 to 30 degrees will often "unkink" the brachial artery that has been stretched over the distal humerus.

Commercial splints frequently do not conform to the position of a fractured elbow, necessitating the use of casting...
FIGURE 5A. Proper position of the splinted elbow and film cassette for anteroposterior radiograph of the injured elbow. The elbow is splinted at 20 to 30 degrees of flexion. To obtain the anteroposterior view, the film cassette is placed flat on the table.

FIGURE 5B. Proper position of the splinted elbow and film cassette for lateral radiograph of the elbow. The lateral view is obtained by moving the camera, not the elbow. To obtain the lateral view, the film cassette is placed beside the elbow and leans against the chest.

Splints, which are usually available in a primary care facility. A simple medial and lateral strut (fiberglass or plaster) of seven to 10 thicknesses of cast material, wrapped with gauze or an elastic bandage, is sufficient to protect the elbow from movement during transfer of the patient and the process of obtaining radiographs. When obtaining radiographs of an injured elbow, manipulating the injured extremity to obtain a radiograph is unnecessary and is discouraged. Adequate views can usually be obtained with the arm splinted in the injury position (Figures 5a and 5b).

The clinician should never assume that an injured child has a radial head dislocation ("nursemaid’s elbow") and attempt reduction before obtaining radiographs. The inappropriate manipulation of a fracture can result in inadvertent neurovascular compromise, with detrimental effects to the extremity.

Types of Fractures

Table 2 lists, in order of frequency, the common elbow fractures in children.

SUPRACONDYLAR FRACTURE

Supracondylar fractures are more common than all other elbow fractures combined. The weakest part of the elbow joint complex is the supracondylar area where the tubular humerus flattens and flares into a broad, flat surface that has a very thin center (the confluence of the olecranon fossa posteriorly and the coronoid fossa

<table>
<thead>
<tr>
<th>Type of Fracture</th>
<th>Percentage of all elbow fractures in children</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supracondylar</td>
<td>65</td>
</tr>
<tr>
<td>Lateral condylar</td>
<td>17</td>
</tr>
<tr>
<td>Medial epicondylar</td>
<td>5</td>
</tr>
<tr>
<td>Radial neck</td>
<td>5</td>
</tr>
<tr>
<td>Miscellaneous (medial condylar, T-condylar, Monteggia, olecranon)</td>
<td>8</td>
</tr>
<tr>
<td>Transphyseal</td>
<td>?</td>
</tr>
</tbody>
</table>

anteriorly). Children are uniquely susceptible to fractures here because of the strong, but hypermobile, joint capsule and ligaments, which allow the elbow to hyperextend. Thus, axial loading can force the elbow into a locked hyperextension posture, which then fails as the joint further hyperextends, driving the olecranon into its fossa and producing the extension-type supracondylar fracture (Figure 6). The presence of a posterior fat pad sign—evidence of hemarthrosis—may be the only radiographic abnormality in nondisplaced supracondylar fractures.

The flexion type of fracture is uncommon, accounting for only 3 percent of all supracondylar fractures, and is caused by a fall onto a flexed elbow. The average age of children with supracondylar fractures is five to eight years, and about twice as many boys as girls sustain this type of fracture. Seven percent of children with this type of fracture have an associated nerve injury, and up to 3 percent have an open fracture. Vascular compromise has been reported in up to 10 percent of cases, but with reduction and stabilization, less than 5 percent of all supracondylar fractures require vascular surgery intervention.

Orthopedic intervention is recommended for most supracondylar fractures. Any displacement of a supracondylar fracture requires surgical intervention, which is usually accomplished by closed reduction and percutaneous pinning. Occasionally, open reduction and pinning are required for displaced fractures or fractures with associated neurovascular injuries. Nondisplaced fractures are casted for three to four weeks.

Supracondylar fractures are usually proximal to the growing physis, so growth arrest is rare. Deformities can occur, however, and are usually a cubitus varus angulation, with loss of the normal carrying angle (Figure 7). This deformity is almost always secondary to malreduction or loss...
of reduction, not growth arrest. Cubitus varus deformity is mainly a cosmetic concern, but the "gunstock" appearance is unsightly enough that many parents or young adults seek surgical correction by humeral osteotomy.

Nerve injury, most commonly of the median or radial nerve, is usually a neurapraxia that resolves within a few weeks. If recovery does not occur within three months, neurophysiologic evaluation and, possibly, surgery are indicated. If permanent nerve injury occurs, tendon transfers usually restore adequate function to the hand to minimize the deficiency.

LATERAL CONDYLAR FRACTURE

Lateral condylar fracture is the second most common elbow fracture, but it is the most common fracture of the elbow that involves the epiphysis and/or the joint surface. The wrist extensor muscles, the brachioradialis muscle and the lateral collateral ligaments attach to the lateral condyle of the humerus. A fall onto an outstretched hand can avulse the lateral humeral condyle by application of a varus force.

Lateral condylar fractures usually occur in children between four and seven years of age and are often subtle on radiographs unless oblique views are obtained. This type of fracture should be suspected when the lateral side of the injured elbow is painful and swollen. The fracture line begins at the lateral humeral metaphysis and extends either through (Milch type I) or just medial to (Milch type II) the capitellar growth center. The Milch type II fracture is much more common than the Milch type I fracture. Although a lateral condylar fracture usually appears as a small avulsion fracture off the lateral condyle (Figure 8), it usually continues into the joint in the center of the elbow, representing a much larger fragment than it appears to be radiographically.

Arthrograms are occasionally used to better define anatomy of the fractured elbow. Orthopedic management is recommended for children with lateral condylar fractures and is similar to management of supracondylar fractures: nondisplaced fractures are casted for three to four weeks; displaced fractures, because they involve the articular surface, require careful open reduction and pinning.

Neurovascular injury is rare in lateral condylar fractures, but elbow stiffness and deformity occasionally occur as a result of nonunion or physeal injury. Lateral condylar fractures usually involve the growth plate and can cause growth arrest. Both nonunion and physeal arrest can cause a progressive cubitus valgus deformity (increased carrying angle), which, over time, can stretch the ulnar nerve, producing the classic "tardy" ulnar palsy years later. Cubitus varus deformities are more common than valgus deformities and are secondary to overgrowth of the lateral humeral condyle.

MEDIAL EPICONDYLAR FRACTURE

The medial epicondyle is the origin of the finger flexors and the medial collateral ligament of the elbow. Falls onto an out-
stretched arm and dorsiflexed hand, producing a valgus stress, can cause an avulsion of the medial epicondyle rather than injury of the strong medial collateral ligaments. As many as 50 percent of these injuries will dislocate the elbow,\textsuperscript{5,6} but many spontaneously reduce by the time the child is seen by the primary care physician.\textsuperscript{2} It is important to realize, however, that this injury is often much more than a mere avulsion fracture. Also, if the elbow is dislocated, the avulsed bony fragment can be displaced into the joint and can become incarcerated, preventing full relocation (Figure 9).

The medial epicondyle first appears at about age five. Fractures of this condyle occur in children between nine and 12 years of age, usually before the epicondyle fuses to the distal humerus, which occurs at about age 15. The ulnar nerve lies just posterior to the epicondyle and can sustain a traction injury if it is pulled with the fragment as the fracture displaces. This is usually a neurapraxia that resolves with time unless the nerve and bony fragment are trapped in the joint.

A medial epicondyar fracture should be suspected when a patient presents with swelling and tenderness medially, or with a history that suggests elbow dislocation. These fractures require orthopedic intervention, with surgery indicated in cases of bony fragments in the joint, fractures associated with significant elbow instability and ulnar nerve damage.\textsuperscript{5,6} If the elbow has not been dislocated, and if the ulnar nerve is not injured, most medial epicondyar fractures can be treated with brief immobilization and heal well without surgery. Early, protected range-of-motion exercises are essential to prevent joint stiffness. Late valgus overgrowth deformities occasionally occur and can lead to tardy ulnar palsy.

RADIAL NECK FRACTURE

Fractures of the proximal radius usually occur through the physis or just distal to the physis in the radial neck. These injuries
are caused by a fall onto an outstretched hand, but they are among the least common elbow fractures in children. The average age of children with fractures of the proximal radius is nine to 10 years, with almost an equal number of boys and girls affected. Also, the incidence of radial neck fractures is similar for left and right arms.

The radial epiphysis appears as the second elbow growth center, just after the capitellar epiphysis, between three and five years of age. Because there are no muscle or ligament attachments, the injury is caused by pure axial loading. The displacement is usually an “apex-medial” angulation, since the axial load on an extended elbow tends to accentuate the carrying angle and produce a valgus force. A portion of the radial neck is outside the joint capsule, so some fractures of the proximal radius do not cause a posterior fat pad sign on the lateral radiograph unless another associated elbow injury occurs simultaneously (usually an olecranon fracture, a medial epicondylar fracture or dislocation of the elbow).

The fractured radial neck can be angulated or totally displaced (Figures 10 and 11). The patient presents with pain and swelling of the lateral aspect of the elbow, distal to the lateral condyle of the humerus. Proonation or supination exacerbates the pain more than elbow flexion/extension, because the angulated radial head no longer rotates perfectly within the capitellum during forearm rotation.

If the angulation of the head and neck with the radial shaft is less than 30 degrees, the fracture can usually be treated with brief immobilization and early range-of-motion exercises.

TRANPHYSEAL FRACTURE

Transphyseal elbow fractures are probably the most difficult to diagnose because they usually occur in infants and toddlers, at an age when the elbow has abundant unossified cartilage. This injury is often confused with elbow dislocation. The true incidence and mechanism of injury in transphyseal fracture are not well known,
partly because this injury pattern is often not recognized.\textsuperscript{1,7} Like supracondylar fractures that occur in older children, many transphyseal fractures probably occur as a hyperextension and/or rotation injury that displaces the entire distal humeral physis. In an infant, the physis is more proximal, actually at the supracondylar area.\textsuperscript{1,3} Transphyseal fracture should be suspected in any child under one year of age who has swelling of the elbow secondary to suspected trauma. Because this injury occurs in very young children, the clinician should always be alert for suspected child abuse.\textsuperscript{1,3}

Often the only anteroposterior radiographic abnormality is that the ulna and radius are not centered beneath the distal humerus in comparison to the appearance of the uninjured elbow. The displacement is usually posteromedial.\textsuperscript{1} The lateral radiograph shows posterior displacement and, unless the capitellar growth center is ossified, the elbow appears to be dislocated posteromedially (Figures 12a and 12b). However, three facts argue against elbow dislocation: (1) elbow dislocations are rare in children under 10 years of age, (2) elbow dislocations are usually posterolateral, not posteromedial, and (3) the relationship of the proximal radius and capitellar growth center is disrupted in a dislocated elbow. In the case of a transphyseal fracture, the proximal radius and capitellar growth center remain aligned with each other.\textsuperscript{1}

Treatment of transphyseal elbow fractures in infants includes splinting and immediate referral to an orthopedist for reduction and pinning. A skeletal survey to rule out child abuse may also be indicated.

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REFERENCES
